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Redefining the L1: Can Vowel Categories Change?

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INTRODUCTION

Much previous research on second language acquisition explores the effects of the first language (L1) on second language (L2) acquisition (Flege, 1992; Tsukada, Birdsong, Bialystok, Mack, Sung, Flege, 2005). Less studied has been the reverse, that is, the effects of the L2 on the L1. The following research aims to propose a new model that advocates for dual-directionality in effect, and argues for the notion that the interactions between the L1 and the L2 should be studied from both directions – the effect of the L1 on the L2 as well as the effect of the L2 on the L1. This model will be most useful in helping to account for pronunciation errors in the L1, which is typically unexpected. Though pronunciation errors in the L1 has been understudied, my findings suggest that some pronunciation errors occur in the L1 because L2 vowels are interacting with L1 vowels in a way that is causing them to cluster and/or collapse into a narrower range of vowels. This in turn results in the production of, what I term, melded vowels, the perceptual result of which is accented speech production. This paper also considers the possibility that certain vowel production phenomena are inherent to bilinguals (Korean-English in this particular case), introducing a bilingual effect on such speakers. Ultimately, this paper aims to challenge the notion that vowel categories, especially those belonging to the L1, are permanent. I argue that perhaps all vowels are in constant flux, always vulnerable to change as an effect of language interaction.

CHAPTER 1

1.1 Significance of the Study

This body of research endeavors to provide an account for errors in pronunciation in the L1 by Korean-American bilinguals. Research in the field thus far focuses primarily on understanding errors in pronunciation in the L2 (Flege, 1988, 1992, 1995, 1999, 2002; Baker & Trofimovich, 2005; Best, 1993; Moyer, 1999). In an effort to understand errors occurring in the L1, this research focuses on the consequential effects of multiple sound systems from different languages interacting with one another, creating a relatively new sound system that consists of sounds from both languages, but also comprises sounds that are unique to the individual. The individual's new phonemic inventory borrows sounds from existing sound systems, and in the process melds these borrowed sounds to form an idiolectal vowel inventory. This phenomenon of melding vowel phonemes as a result of collapsing sounds will be referred to here as "constructed" vowels; this will also be more closely defined on 4.1. Therefore, this research aims to show that pronunciation errors in the L1 are due to a process of replacement such that whenever the correct pronunciation requires one of the collapsed vowels, the "constructed" vowel sound is used in its stead, producing what may be perceived as an incorrectly pronounced utterance.

To study these effects, my research focuses on vowel pronunciation in bilinguals of Korean and English, all of whom are of Korean descent. The findings suggest that, collectively, all vowels from existing sound systems undergo a noticeable shift, demonstrating extreme "backness." This body of research concludes with suggestions regarding the implications of this study, drawing reference to Stephen Krashen's proposed Input Hypothesis as a possible framework within which our findings can be contextualized. Overall, this study endeavors to

encourage more research to explore the possible effects the development of emerging L2 sounds could be having on existing L1 phonemes. While much of the focus remains on understanding the effects of L1 on learning the L2, studying the reverse effects could yield very insightful findings that may even enlighten our understanding of L2 development. My hope is that as we call upon a model that encompasses directional effect in both ways, this research also inspires a reconsideration of bilingualism as a unidirectional process and encourages future researchers to explore these possibilities.

1.2 Outline of the Thesis

In this paper, I will first place this study's place in the context of the current literature by discussing previous studies of second language acquisition and bilingualism. In the process, I will show ways in which this research can provide insight into areas of sociophonetics that have previously been underexplored. Chapter 2 will provide a detailed discussion of the design of this study, including background descriptions of all the participants to see how social effects, such as family upbringing and language and cultural identities can help provide greater understanding of the possible effects of the emerging L2 on the L1. Chapter 3 presents the results of this study, graphically as well as in table form. In addition, calculated standard deviations are also provided as a means to quantify exact differences. An analysis of all the compiled findings is presented in Chapter 4, and I conclude with suggestions to help direct future research endeavors.

I will first begin with a brief discussion of L2 acquisition and the effects of the L1 on L2 learning. This discussion will address research on the critical period, age of arrival, length of residency and other factors that typically affect L2 acquisition and contribute to noticeable foreign accents in speech production. The following sections are intended to contextualize my research and better understand the need to propose this new model that supports that both the L1

and the L2 can affect each other and that challenges the assumption that vowel categories are permanent.

1.3 Background Literature

1.3.1 Redefining the "Critical Period"

Specific focus has conventionally been on the influence of the L1 on the L2 and the resulting occurrence of a "foreign accent" (Flege, 1992). This phenomenon usually relies upon the following assumptions – that there is a critical period for language acquisition, and factors affecting L2 acquisition. However, much of this research has been in the direction of the existing L1 sounds affecting the emerging L2 sounds (Flege, 2002). The critical period, popularized by Eric Lenneberg in his seminal paper, is defined such that changes that are biologically driven in brain development are credited for the overall decline in aptitude to learn another language with increasing age (Lenneberg, 1967). Thus children are better able to learn new languages than adults because such learning takes place before the end of the critical period of neurological development. While the critical period focuses on L1 acquisition, the principles have been applied to adult L2 acquisition (Snow & Hoefnagel-Hohle, 1978; Johnson & Newport 1989). Furthermore, adults demonstrate reduced brain plasticity and are generally rigid more than children in terms of language learning as linguistic features of the L1 are fossilized. Thus, it is reasoned that while L1 can detrimentally affect L2 learning during adulthood, L1 remains unaffected.

These principles are, however, recently coming into serious contention, especially with regard to whether there is, in fact, this period that we have come to refer to as a "critical period." The debate on a critical period has often focused on its exact length. When this hypothesis was first developed by neurologist Wilder Penfield in 1959 and then widely circulated by Lenneberg

(1967), it was suggested that due to maturational constraints, unless language acquisition happened by puberty or early adolescence, certain aspects of language can be learnt, though never to the extent of full mastery. The exact timeframe of a critical period comes under scrutiny when discussing findings from studies that show that even after a critical period, individuals begin to lose certain sounds in the L1 (Best, 1995). This loss is interesting because it is as though with reduced brain plasticity can result in deteriorating L1 representations over time. This change in mental representation is suggestive of the idea that not only does reduce plasticity affect language learning abilities, but also the ability to retain L1 sounds, sounds that are expected to be native and supposedly fully acquired. This possibility challenges the very significance of a critical period as it questions the implications of learning a second language if native sounds can be lost anyway.

In addition, many other significant variables such as motivation to learn an L2, attitudes towards the new language, cultural differences and assimilation, can also affect the ability or inability to learn an L2 late in adulthood (Gardner 1982). These other considerations affect the validity of a critical period.

An emerging body of research has shown that within the L1, phonetic representations demonstrate rather extreme plasticity and are easily malleable, so much so that these representations can potentially adopt phonetic qualities and characteristics of other L1 speakers under specific phonological, and more importantly, social conditions (Pardo, 2006).
Pardo's research examines the degree to which interacting talkers increase similarity in phonetic repertoire when in conversation. Repetitions of the same lexical items produced in a given conversational task between speakers was studied to determine whether any possible phonetic convergence was at play, which was assessed independently by a separate set of listeners to

detect similarity in pronunciation across items. Generally, she found that a listener considered a repeated item spoken by one talker in the task to be more like a sample production spoken by the talker's partner than corresponding interactions before and after the utterances. These results show that talkers in conversational settings are prone to phonetic convergence, which can be manifest in non-linguistic functions in social dialogue and can trigger such phenomena as changes in accent or dialect formation. Pardo's findings are important as they further the possibility that even beyond the effects of a critical period, there are other reasons that changes in vowels, however temporary, are likely. Social factors also invite a challenge to the notion that once sounds in the L1 fossilize, they are almost irreversible (Flege 1995).

There is also increasing evidence suggesting that the L1 can actually be affected by a developing L2. Chang (2010), who studies the malleability[1] of L1 sounds, refers to this collective phenomenon as "phonetic drift." He attributes this recognition of an emerging L2 having effects on the L1 to the initial discoveries of Selischev (1925), who was on the forefront of materializing a theory discussing changing vowel categories while studying Slavic languages. Current research has begun to look extensively into this promising possibility. James Flege and colleagues who have extensively studied factors affecting second language acquisition have found results corroborating Selishchev's early theories (Flege, 1995, 2002 & 2007; Flege, Schirru, and MacKay, 2003). In the Speech Learning Model, Flege further challenges the notion of an unchanging L1, saying that, "phonetic categories established in childhood for L1 sounds evolve over the life span to reflect the properties of all L1 or L2 phones identified as a realization of each category (1995:239). Chang also contributes, "The notion of a static, fossilized L1 has largely been replaced with that of a dynamic and ever-changing L1" (2010:3).

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[1] Malleability refers to the degree to which vowels are susceptible to external influence, such as emerging vowel sounds in the L2.

1.3.2 L2 Acquisition and Foreign Accent

When people begin learning a second language upon immigrating to a new country in which this L2 is predominantly used, they tend to produce L2 speech with a foreign accent, noticeable to varying degrees. Even after several years of L2 use, the accent usually remains detectable in L2 speech production. Researchers have posited various factors that may affect the overall degree of perceived foreign accent. Of these many factors, a few have received particular attention, the first of which is the age of first exposure to the L2 (usually measured by age of arrival to the L2-speaking country (AOA)) (Johnson & Newport 1989). The second factor under great scrutiny is the percentage of use of the L2 and the L1 (Bullock, Toribio, Davis, Botero, 2004; Johnson & Newport 1989). Between the AOA and language use, AOA has been shown to be a more effective indicator of overall foreign accent. Essentially, research on L2 acquisition within the critical period has consistently demonstrated a focused emphasis on looking at the effects of age on foreign accent (Johnson & Newport 1989).

Lenneberg (1967) found that foreign accents in the L2 were difficult to overcome, especially so after adolescence. This lead to research revisiting the importance of whether learning a second language during the critical period had significant effects. As is currently widely accepted, learning an L2 after the end of the critical period proves more challenging as people are faced with severe neurological constraints affecting plasticity of motor skills, which in turn renders native L2 speech production "highly unlikely or impossible" (Moyer, 1999). This ultimately suggests that immigrants with an AOA of 15-24 years will observe a stronger foreign accent in their L2 compared to those having an AOA of 3-12 since having an AOA of 15-24 is after the end of the critical period (Yeni-Komshian, Flege, Liu, 2000).

Many of the challenges of learning an L2 as a late learner could be attributed to conflicting sound systems, or as Flege and colleagues describe, "the effect of cross-language phonetic interference" (Flege, Birdsong, Bialystok, Mack, Sung & Tsukada, 2006:156). Research has also suggested that because late learners generally receive less L2 input, and/or possibly L2 input that is more heavily influenced by a foreign accent, they are often more likely to have stronger foreign accents in the L2, especially when compared to their counterparts who are early learners and have a greater exposure to native L2 input. Additionally, a relatively later AOA usually corresponds to a relatively short LOR[2], further reducing opportunity to produce native-like L2 speech. These late learners have used their L2 for a shorter duration than early learners have. It could also be posited that as the phonetic and phonological system of the L1 develops during childhood, the effects the L1 phoneme system will eventually have on the development of the L2 will increase. According to Flege, as the phonetic categories in the L1 solidify through childhood, these categories prove to be stronger "attractors"[3] of vowels and consonants in the L2 (1999, 2002, 2003). Therefore, this 'attraction' decreases the probability of new categories developing for the emerging L2 vowels and consonants, which subsequently hinders collective L2 development and supports stronger retention of a foreign accent.

One may add a caveat to this idea of 'attraction', however, and that is that this particular theory essentially derives from the assumption that L1 sounds are permanent, neglecting to consider whether surfacing L2 sounds could be affecting existing L1 sounds. Could it be that the effects are actually in reverse – that, in fact, the developing categories in the L2 are potentially changing already existing L1 categories? This effect could also influence the perception of a

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[2] This is all relative to the time of testing.

[3] Attractiveness of vowels relates to likelihood with which a particular emerging sound will map onto an existing sound. Thus, L1 categories that have fossilized into the sound system are more likely to be attractive to emerging sounds and thus be more likely to map onto these L1 representations.

foreign accent. What would be our findings were we to also consider the effects on the L1? Are L1 categories permanent, and if so, how longstanding is this permanence and can these categories withstand any influence or effects of L2 development?

1.3.3 Redefining Directionality of Effects – Can L1 Be Influenced?

In his research on vowel shifts and malleability, Chang aptly states, "When we learn a second language in our adult years, what happens to how we pronounce our native language, the language we learned first in childhood?" (2010:1). In his research, Chang proposes a process of phonological restructuring in the L1 that takes place during L2 acquisition, a phenomenon he introduces as "phonetic drift" (2010). Chang addresses many underlying queries regarding the potentially far-reaching effects of L2 development on the L1 that also collectively serve as a salient, thematic role in my study as well. He revisits the notion that our native language remains integrally, and in many ways permanently, embedded in our cultural and language identity. We assume this L1 role as static and unchanging, even over time, but perhaps this is not really the case. Chang offers insightful questions that help inspire his research: "Why should learning a foreign language affect an individual's native language production? How and when does this cross-language influence manifest itself? And what does this sort of cross-language influence reveal about how language sounds – of the native language and of a foreign language – are represented in the mind?" (2010).

The factors motivating these cross-language influences are also important to consider as a way of contextualizing this phenomenon. Chang enumerates many social circumstances under which we would observe this changing effect on the L1. He states:

> It has often been observed that when people come to live in a place where a different dialect of their language is spoken (such as when teenagers leave their hometowns to attend college in distant parts of the country), they return home sounding perceptibly

> different from when they left. There are clear social explanations for this sort of "accent shift" between dialects (2010:1)

Such a shift in accents provides an insightful framework for my research and contributes the foundation needed to understand, in greater context, the implications of our findings, which will be discussed in the following chapters. By introducing the potential of phonetic drift, he allows for an opportunity to revise the framework through which we view the L1 such that the possible effects of the L2 can also be properly studied. Chang goes on to say:

> However, it has also been observed that when people leave their country to live abroad and are immersed in a totally unrelated language for an extended period of time (such as in the Peace Corps or various study-abroad programs), they too return home sounding perceptibly different from when they left" (2010).

1.3.4 The Effects of Bilingualism

Perhaps there are certain phenomena that are inherent in bilinguals. Bilingualism is most often viewed as being on a spectrum or a continuum of bilingualism that ranges from relatively monolingual language learners to highly proficient bilinguals who have a strong command of both languages (Garland, 2007). In the process, however, we often label bilingualism to progress in one direction, the effects of the L1 on L2 learning. We prescribe to a unidirectional, almost one-dimensional view of cross-linguistic dynamic. The possibility of L2 effects on the L1 is all too easily overlooked. It is important to challenge these ideas and revisit the dynamics of interplay between contrasting language systems.

1.3.5 Shifting L1 Categories – Effects and Implications

In support of the Speech Learning Model (Flege, 1995), controlled studies have demonstrated that production of L1 categories shifts in the direction of phonetic norms of L2 categories when speakers have been exposed to consistent L2 input for an extended period of

time. The Speech Learning Model proposes that this demonstrated shift in norms is a result of an equivalence classification (Flege, 1986) of comparable L1 and L2 sounds that subsequently results in their sounds becoming, essentially, "perceptually linked" (Chang, 2010). Flege defines equivalence classification as, "a basic cognitive mechanism, which permits humans to perceive constant categories in the face of the inherent sensory variability found in the many physical exemplars which may instantiate a category" (1986). In other words, equivalence classification is especially important for L1 learning because it ensures that phones that are produced by different speakers, or in different phonetic contexts are still perceived to be in the same category. Essentially, this classification helps to neutralize any differences, which is especially helpful during child language acquisition, so they can process all variations of the same phone as belonging to the same L1 category. This ultimately creates an opportunity for both the learner's L1 and L2 phonemic inventories to be influenced by input from either the L1 or the L2.

Before further discussion, it is important the note the difficulties L2 learners often face during L2 acquisition. One of the main challenges is overcoming the differences in phonotactic constraints between the L1 and the L2 (Yeni-Komshian, Flege, Liu, 2000). Existing L1 representations may affect proper L2 acquisition because the L2 learner is already accustomed to the speech patterns in L1, and thus, trying to learn the new speech patterns of the L2 is likely to be difficult (Flege & Hammond, 1982). Another possible challenge is that L2 learners are actually identifying both new and similar phones in the L2 with respect to an L1 category, and thus show that L2 learners have difficulty perceiving sounds in the L2 correctly, thus affecting their production. In the following, I will first discuss previous theoretic approaches that have been taken to study this issue and the difficulties that have been faced in pursuing these methods.

These approaches include studying equivalence classification and phonological filtering. Following is a discussion of various ways to view difficulties in learning an L2.

There are many confounding factors that affect the ability to conduct research in L2 learning. First, studying this particular phenomenon is especially challenging because most of available literature discusses infant language acquisition and adult L2 acquisition but there is much less information on post-infancy as well as post-adolescence language acquisition. Any findings related to this period could help provide insight into whether the development of cross-language categories is a particular phenomenon that occurs during early or late L2 development. Additionally, existing research also lacks any far-reaching insights into contrastive language development, as the studies tend to focus more on languages that are related and are grounded in the same alphabet, which even before further study, demonstrate many shared sounds. All of these factors further emphasize the importance of conducting a study on Korean-English bilinguals of Korean descent as it focuses on languages that are largely unrelated – Korean and English – and on participants learning the L2 at varying stages of their young adulthood (and relative to the end of their critical periods).

1.3.6 Significance of Equivalence Classification

Flege's (1986) research on the effects of the equivalence classification, the ability to classify all variations of a phoneme as that particular phoneme, is worth another look as it helps to reconcile the differences in the production of essentially new phonemes in an L2. Specifically, he addresses whether a decrease in human vocal learning ability applies uniformly to all emerging phones in an L2. His particular research focused on the French and English languages, measuring voice onset time (VOT) and vowel formants (F1-F3). His informants were native French participants who were highly proficient in English, and three groups of native English

consultants who all displayed varying levels of French proficiency. The speech production of monolingual speakers was also studied to determine the phonetic norms of French and English and to provide a basis for comparing formant measurements of native French and English speakers. Flege proposed that the effects of equivalence classification inhibit the extent to which L2 learners approximate L2 phonetic norms. This allows for comparable L2 phones to be realized as an existing category of L1, rather than as a new L2 phone with no comparable counterpart in L1. For example, the French /y/, which is unavailable in English, is difficult for native English speakers to approximate since no comparable representation is given in the L1. The /u/ and /t/, however, are available in both English and French, and thus easier to approximate. Native English speakers with prior extensive experience with French did not show significant variance from French monolinguals when producing French /y/, which suggests that these speakers were able to approximate the French /y/ due to their prior exposure to the language.

Flege defines "new" phones in the L2 as having no counterpart in L1, which means that they differ fundamentally in terms of acoustic quality from sounds found in the L1 (1986). Thus, French /y/ are essentially new phones for native speakers of English since there is no existing realization or available rendering of this French phoneme in English. It should be noted that although it may seem that English occasionally utilizes a [y] phone on the phonetic surface of the English language, there is, however, no definitive /y/ category from which this phone originally derives. This principle also relies on the assumption, as Flege notes, that informants eventually arrive at the realization that [y] is not a manifestation of an available category in English. Thus, as a result, native English speakers most often tend to identify French /y/ as /u/, even though acoustically there are significant disparities in formant measurements.

In the same vein, Flege defines "similar" phones as differing systematically from an easily identifiable sound that corresponds in the L1. For example, /t/ is an available sound in both English and French; however, depending on the language in which the sound is found, it is articulated, and thus rendered, differently. Flege describes that this same sound in French can be realized as a short-lag[4] stop with a dental place of articulation, whereas in English it is implemented as a long-lag stop with an alveolar place of articulation. L2 learners recognize or realize emerging L2 phones in terms of L1 categories, and therefore, during the process of L2 acquisition, will use gestures of articulation previously established during L1 acquisition (Catford, 1965). It is traditionally viewed that the difficulty L2 learners face in pronouncing phones in an L2 is largely related to those phones that are unavailable systematically on the phonetic surface of their L1 (Briere, 1966). In other words, although the phones may initially appear unavailable, speakers will modify their speech production in order to realize these sounds. This leads to one of a few possibilities, the first of which is that L2 learners very likely make necessary adjustments in their articulations to accommodate for the differences in order to realize similar L2 phones differently than their corresponding sounds in the L1, or, secondly, that their production of similar L2 phones according to phonetic norms established in the L1 remain unnoticed by listeners, both natives and non-natives alike.

1.3.7 Redefining Phonological Filtering

As mentioned earlier, nearly all errors in pronunciation or speech production in the L2 involve phonemes that are unavailable, or are realized differently, in the L2 and the L1 (James, 1985). These differences would account for the many challenges learners of an L2 may face

[4] The term lag is in reference to processes of assimilation across segments and is measured as Voice Onset Time, the time it takes for voicing to begin with respect to the burst of the sound. A long-lag stop is perceived as a voiceless stop and a short-lag stop as being voiced. Thus, a short-lag stop indicates a phoneme that sounds voiced, such as the /d/, rather than voiceless, such as the /t/, to a native English speaker.

when attempting to establish the articulatory patterns required to produce the L2 phones authentically, whether new or similar. While equivalence classification provides one account of the L2 learner's experience of acquiring the target sounds of the L2, another possibility is phonological filtering, the process by which L2 learners are phonologically filtering acoustic differences that are unsupported by existing sounds in the L1, thereby eliminating any conflicting sounds or allowing for adjustments to accommodate use of existing L1 sounds rather adopting new categories (Trubetzkoy, 1936/1939). The learning of L1 phonology is thought to be responsible for L2 learners' inability to perceive acoustic differences in sounds that are unavailable in the L1. Essentially, phonological filtering would result in speech production that is heavily shaped by existing L1 representations since all other unavailable representations required for L2 production are eliminated. This subsequently leads to L2 speech production that lacks accuracy. Inability to prevent L2 learners from discerning auditorily these acoustic differences that discriminate similar phones in L1 and L2 could also be attributed to this process of phonological filtering. Recent research, however, has challenged this proposal by demonstrating that adults are actually able to detect acoustic differences in similar phones (Flege & Hammond, 1982). Despite these challenges, Trubetzkoy's contributions still may be worth considering – could reverse filtering be happening and accounting for possible effects of the L2 on the L1?

The results from Flege's (1986) research on French and English acoustically measuring VOT and vowel formants, or frequencies, (discussed more in Chapter 2), however, actually found that participants in all four groups[5], collectively, produced /u/ in their L2 with F2

[5] As described in an earlier section, the four groups are in reference to one group of native French participants who were highly proficient in English and three other groups of native English participants who differed according to level of proficiency in French.

measurements showing to be significantly different from the expected F2 measurements typical of native speakers. Furthermore, the measured value of their VOT for the production of /t/ in their L2 revealed either a close resemblance to the L1 phonetic norm, or proved to be relatively intermediate to the measured phonetic norm for the VOT in both the L1 and L2. Interestingly, and salient to my research, L2 learning was also shown to affect production of /t/ in the L1. In effect, the native French informants who were highly experienced in English produced /t/ with longer VOT, usually characteristic of the production of /t/ in English, especially so when compared to the production of /t/ in French monolinguals. Moreover, the native English speaker with the most experience speaking French, produced /t/ with shorter VOT, likewise normally typical of a /t/ in French, than did the English monolinguals. While Flege concentrated on consonants, his findings provide great insight into the possible directionality of effect on *vowel* production in the L1 and L2 by showing that the phonetic space of adults can be restructured during L2 acquisition, and corroborates the theory that the effects of equivalence classification assumes almost a preventative role by precluding experienced L2 learners from producing certain L2 phones similar in nature to existing L1 phones, as Flege puts it, "authentically" (1986).

1.3.8 Reassessing Malleability of Representations in L1

Research has yet to thoroughly address the discussion of the extent to which L1 representations demonstrate malleability, especially during the process of L2 learning. Social reasons, such as the desire to sound like one's peers, or to better assimilate into the culture of which the language plays a dominant part may motivate L1 speakers to accommodate their speech production to speak. Like members of the same speech community, no comparable reason can be applied to understand motivations for L2 speakers to modify their L1

representations according to their L2. In fact, the process by which within-language convergence takes place differs between L1 talkers significantly from the process by which cross-language convergence occurs between L1 and L2 phonemes, especially so considering that the reasons we employ to understand and account for within-language convergence are inaccessible when trying to understand cross-language convergence. As Chang elaborates, L2 learners modifying their L1 representations according to their L2 "changes nothing about the social distance between them and native speakers of the L2, given that L1 is not a shared language, nor could doing so accomplish a modification of the social distance between them and other L1 speakers in any intended way, given that the change is not motivated by L1 input" (2010). Even more interestingly, this would most likely have the unintended effect of polarizing speakers of the L1 (or members of the same speech community) since L1 speech production affected by the L2 would be perceived as having a foreign accent, and thus create further social distance from other speakers of their native language.

One might also consider the process by which L2 input is processed. Previous research shows that during infancy and early childhood language learners' perception of speech adjusts to the language-specific phonetic properties of the language that immediately surrounds the learner (Werker & Lalonde, 1988; Whalen, Levitt & Wang, 1991; Kuhl 1989). Subsequently, this creates a bias towards sounds of the native language early in life and before formal exposure to the L2. Flege (2006) goes on to suggest that once this process of attuning takes place, the sensory properties that are attributed to L2 phonetic contrasts are essentially distorted in a way that causes emergent L2 categories to conform to the phonetic patterns experience earlier in the L1. This ultimately has serious consequences in terms of proper L2 development since persistent

distortion of L2 sounds will continuously inhibit reception of input needed to attain perceptual representations required for native L2 speech production.

In a study conducted in 2006, Flege and fellow researchers looked at the degree of noticeable foreign accent in the production of English sentences by native Korean children and adults (Flege, Birdsong, Bialystok, Mack, Sung & Tsukada, 2006). This longitudinal study was designed to determine the effect of age and length of residence (LOR) in the country of the second language, which in this case was compared between 3 and 5 years on the degree of foreign accent in the second language. The study measured English sentences recorded by Korean adults and children residing in the North America and by native English adults and children. The recording sessions were held 1.2 years apart (T1 vs. T2). This particular design of the study allowed the research to take into consideration any noticeable changes in English pronunciation over real time. The findings were then used to determine whether native Korean participants would have a significantly less observable foreign accent at T2 than T1. This was also particularly insightful because findings suggesting a reduced foreign accent at T2 would shed additional light on whether this reduction could be attributed to children since research has conventionally shown that children demonstrate greater abilities to learn an L2. Native English speakers were then asked to listen and evaluate the recorded sentences for overall degree of perceived foreign accent based on a 9-point scale. Results showed that the native Korean children received significantly higher scores on their English pronunciation than did the native Korean adults. However, the native Korean children performed at a lower level when compared to the native English children. Effectively, the native Korean children, including those who had arrived as young children and had been previously taught in English-medium schools for an average of 4 years, still produced English with noticeable foreign accents. The study found that

the effects of LOR proved insignificant for both native Korean adults and children. In this same vein, Flege and researchers were able to dismiss the hypothesis that adult–child differences in L2 production were due to passing of the critical period since findings were inconsistent with this theory. This is particularly pertinent as it supports research mentioned earlier challenging the existence of a critical period, especially so under my proposal that L1 sounds are malleable, and even sometimes, lost. The study ultimately found that foreign accents were less observable in children than were in adults and posited that these findings were because children often received greater L2 input than did adults.

1.3.9 Perception and Production

Focused analysis on the differences between production and perception is helpful in understanding some of the reasons motivating pronunciation errors in both the L1 and L2. Tsukada and colleagues investigated the production and perception of English vowels by native Korean learners of English (Tsukada, Birdsong, Bialystok, Mack, Sung, Flege, 2005). Findings from the preliminary experiment demonstrated that native Korean adults were able to discern certain pairs of contrastive English vowels by their use of different Korean vowels while other pairs revealed classification overlap, suggesting that these particular exemplars would prove difficult for Korean learners of English to differentiate. For example, the English vowels /i/ and /ɑ/ were unambiguously identified as instances of different Korean vowels, respectively /i/ and /a/, which demonstrates that even though the English /i/ and /ɑ/ stimuli may differ from the Korean /i/ and /a/ in terms of phonetics, when they hear the English /i/ and /ɑ/, native Korean learners of English will produce different phonetic codes for each vowel sound. In a follow-up experiment a year later, native Korean adults and children differing in LOR in North America (similarly 3 vs. 5 years; 4 groups of 18 each) were compared to native English speakers of the

same age. In this study, native Korean children were found to discern English vowels with greater accuracy than native Korean adults, but with less accuracy when compared to children who were native English speakers. In the final experiment, native Korean adults and children were asked to produce the following sounds /i, ɪ, e, ɛ, æ, ɑ, ʌ/ in carrier words. They were presented with pictures and asked to name them, eliciting the required sounds under study. The results showed that certain vowels produced by native Korean children were heard as intended significantly more often than vowels that were produced by the native Korean adults. For example, classification results revealed that adults have difficulty producing a perceptually effective contrast between English /ɛ/ and /æ/. Specifically, these results demonstrated that when the native Korean participants erred in their production of English /ɛ/, they had a natural tendency to produce a vowel with [æ] qualities. Likewise, when they erred in their production of /æ/, they tended to generate a vowel with [ɛ] qualities. The native Korean participants experienced similar difficulty in their productions of /ɑ/ and /ʌ/ revealing bi-directional conflation. Thus, their difficulty in producing effective distinctions between these contrastive pairs /ɛ/- /æ/ and /ɑ/ - /ʌ/ exemplifies a process of vowel contrast reduction. Further acoustic analyses demonstrated that native Korean children produced significantly larger between-vowel contrasts than did native Korean adults, though the native Korean children showed little difference from children who were native English speakers.

For purposes of the research described in this paper, the significance of the first experiment is particularly salient as it looks into possible factors affecting a speaker's ability to discriminate vowels in the L2. The experiment was designed to determine four pairs of contrastive English vowels that would prove challenging for the native Korean participants, and one other pair of English vowels that would be relatively easy to discern. (This also functioned

as a control to ensure that the native Korean participants understood the directions of the task correctly.) It is conventionally accepted that a non-native speaker's ability to discern specific vowels in the L2 depends significantly on whether these L2 vowels can be classified with respect to the existing vowels in their L1. Tsukada and his researchers found that for many native Korean learners of English, the vowels involved in the /i/ - /ɪ/, /eᴵ/ - /ɛ/, /ɛ/ - /æ/ and /ɑ/ - /ʌ/ contrastive pairs would not reliably map onto distinct Korean vowel categories, largely because a high level of performance in discerning between vowels of each pair is contingent upon establishment of new phonetic categories for one or both of the English vowels. According to Best's Perceptual Assimilation Model (1993, 1995), instances of contrastive L2 vowel categories that are recognized as instances of a single L1 vowel category proves relatively more difficult to differentiate, whereas, instances of contrastive L2 vowels that are appropriately mapped separately onto different L1 vowel categories will preserve the likelihood that these vowels in the L2 will be discriminated with greater accuracy.

1.4 Mapping L2 Speech Acquisition

An overarching curiosity motivating research on speakers undergoing L2 acquisition has been whether their languages are represented and processed in one shared system or in separate systems. Since Weinreich's (1953) contributions to the field, directed focus on developing a viable account or method of modeling bilingualism has yielded many proposals, such as the Word Association Model and Concept Mediation Model (Potter, So, Von Eckardt, and Feldman, 1984), the Distributed Conceptual Featured Model (de Groot, 1992), the Revised Hierarchical Model (Kroll and Stewart, 1994), and the Inhibitory Control Model (Green, 1998). These models are largely grounded in evidence suggesting a range of possibilities – that the use of either L1 or L2 often activates the other language, even under irrelevant circumstances, and on the other

hand, that L1 and L2 are motivated by different neural resources and can be reduced independently of each other. The ongoing discussion remains to uncover the extent to which structures of an emerging L2 system are transferred from L1 or developed independently, using only L2 input. There is also the possibility that L2 sound development is attributed to the presence of a universal, possibly innate, linguistic "substrate," as Chang notes in his research (2010:30). The significance of this debate is that these findings yield the possibility that there is an "inter-language" system that combines features of L2, elements of L1, and universal qualities absent in both languages, producing a functional, hybrid language system. As a result, study of L2 speech production has largely unfolded under the assumption that at least, certain aspects of the emerging L2 are shared with the L1. Given these preliminary findings, it seems especially important to push this notion further and consider whether this "inter-language" system is unique to each individual undergoing L2 speech acquisition. Perhaps the availability of "universal" elements unavailable in either the L1 or L2 serves as compensatory measures for any non-acquired or partially developed sounds in the L2. We can look to a few available models to help framework our understanding of L2 speech production and acquisition, and our investigation of ways by which developing L2 sounds can affect seemingly permanent L1 representations.

1.4.1 Perceptual Assimilation Model

Best (1993, 1994) developed the Perceptual Assimilation Model (PAM), specifically designed to account for processes of L2 phonological acquisition during the earliest stages. The model helps describe the process by which non-native speech is perceived by native listeners who have had no prior exposure to the non-native language. PAM posits that non-native speech contrasts are interpreted by native listeners relative to their L1 phonological categories, or as Best describes "perceptual assimilations." Therefore, the kind of assimilation that occurs will

help determine the level of difficulty learners will have with discerning the contrast. In effect, learners who determine the contrast by assimilating the emerging L2 sounds to different L1 categories will discriminate with greater accuracy, whereas those who map L2 sounds onto one L1 category will discriminate contrastive sounds with reduced accuracy. Contrasts in sounds that are unavailable in the L1 are predicted to differ in ease of differentiation according to whether they can be assimilated to existing L1 categories, which negates the view that these contrasts are equally difficult for native listeners to perceive. Best concludes, "Phonologically mature listeners perceive in non-native phones information about their gestural similarities to native phonemes" (1994:190). Thus, perceptual assimilation only occurs when non-native phones are discovered to be sufficiently similar to a native phoneme with respect to their patterns of articulation.

Interestingly, there still remains the possibility that non-native phones that are assimilated to the same L1 category could still be discerned by the native speaker. This is because Best posited four possible forms of perceptual assimilation, which are Two-Category assimilation, in which non-native phones are assimilated to different L1 phonemes, Category-Goodness Difference assimilation, in which non-native phones are assimilated to the same L1 phoneme while one is relatively more different than the L1 phoneme, Single-Category assimilation, in which non-native phones are assimilated to the same L1 phoneme with both phones demonstrating equal levels of similarity and contrast with the L1 phoneme, and finally Non-Assimilable assimilation, in which non-native phones are far too different from available L1 phonemes to be assimilated to any particular L1 category and are subsequently perceived as non-

speech sounds.[6] Given these four basic forms of assimilation, PAM concludes that for adults, discrimination performance should be, "from highest to lowest, [Two-Category] > [(Non-Assimilable] < = > [Category Goodness]) > [Single-Category]." "[Category-Goodness] and [Single Category] contrasts fall at different ends of a single dimension, in that both involve assimilation of a non-native phone pair to a single native category" (Best, 1994:192). Essentially, it seems that perceptual assimilated phonemes, determined largely by comparisons of phonetic details of native and non-native sounds, can easily be affected by phonological environment. The significance of PAM yields profound results in terms of the implications for the perception of L2 contrasts by L2 learners. PAM does, however, fall short of accounting for L2 production, since it focuses more heavily on perception, though it does importantly help to solidify the connection between L2 perception and L2 production. The Speech Learning Model provides a stronger foundation from which this connection can be made, and a more refined focus on L2 production can also be seen.

1.4.2 Speech Learning Model – Revisiting Equivalence Classification

The Speech Learning Model (SLM), developed by Flege (1988, 1992, 1995), refocuses emphasis on L2 speech learning by taking into consideration the possibility of "phonetic systems reorganiz[ing] in response to sounds encountered in an L2 through the addition of new phonetic categories, or though the modification of old ones" (Flege 1995:233). Despite significant research on understanding the critical period, the SLM posits that learning mechanisms used during L1 acquisition are actually available throughout life, and that, more importantly, an L1

[6] In addition to these four forms of assimilation, Best also posited other forms that involved perception of a non-native sound as speech, but not necessarily as an L1 phoneme (1995). She identified this as a form of Uncategorized-Categorized assimilation, in which one non-native sound is assimilated to an L1 phoneme, while the other sound is perceived as a non-L1 speech sound. She also proposed the Uncategorized-Categorized type, in which both non-native sounds are perceived as speech sounds, but remain unrecognized as any specific L1 phoneme.

category designed to encode certain language-specific features of an L1 sound continues to develop into adulthood under the influence of all sounds, regardless of language, that are recognized to be classified in that category. This understanding of L1 learning undermines the notion of a static quality conventionally attributed to L1 development and complete acquisition. In fact, SLM takes this postulation regarding L1 and L2 category development a step further by arguing that these categories actually exist in a shared system, in which there is general pressure to preserve them as separate categories despite the shared nature of the system.

From these findings, SLM enumerates several additional theories. The first hypothesis undermines the theory that sounds in the L1 and L2 are related on an abstract phonemic level. On the contrary, these L1 and L2 sounds are described to be related perceptually to one another at a "position-sensitive allophonic level" (Flege 1995:239). Secondly, a new phonetic category may be formed for an L2 sound on the condition that the L2 sound demonstrates enough dissimilarity from the closest available L1 sound though this does become gradually more unlikely at older ages of learning. In effect, if a new phonetic category is formed for an emerging L2 sound, and it still consists of the same information that would be found in that of a native speaker's, then it would be predicted that the L2 learner would produce the L2 sound with great accuracy. Third, the findings also suggest that the consequential effects of equivalence classification will block category formation for an emerging L2 sound to the extent that a single phonetic category will be employed to process L1 and L2 sounds that are perceptually linked. Eventually these effects will result in the L1 and L2 sounds collapsing and ultimately resembling one another in terms of production. Finally, it is predicted that the phonetic categories a bilingual establishes for L2 sounds may likely differ from those produced by a monolingual, particularly under the following notable circumstances: (i) when the bilingual's category is separated or "deflected" from an L1

category in order to maintain phonetic contrast, or (ii) when the representations developed by a bilingual are based on different features, "or weights" from those used for L1 representations.

In sum, the significance of the SLM lies in its emphasis that many of the speech learning mechanisms used during L1 acquisition will also be used during L2 acquisition; hence a sense of continuity across L1 to L2 learning, while still acknowledging that acquisition will be different due to prior exposure to the L1. SLM draws heavily from equivalence classification, which helps to account for the fact that communication remains viable despite phonetic variability amongst speakers, whether they share the same language community or come from different ones. Within the framework of L2 learning, equivalence classification is understood to specifically target L2 phones that are considered similar enough to existing L1 phones, rather than L2 phones that are completely new to the learner. Thus, the equivalence classification of similar L1 and L2 phones ultimately reduces the accuracy with which the L2 phone can be produced because the L2 is affected by the qualities of the similar, though non-identical L1 phone. Flege articulates, "If equivalence classification prevents L2 learners from developing a separate phonetic category for similar L2 phones, they may be unable to produce similar phones in L2 and L1 authentically because they need to implement [the necessary phones] in both L2 and L1 using the same phonetic category" (1986:62). As a result, the consequences of equivalence classification yields incredibly profound implications – the collapsing or "merging" of phonetic properties characteristic of similar L1 and L2 phones in any one given category may lead to as Flege describes it, "an upper limit on phonetic approximation for similar L2 phones" (1986:63).

Considering the possibility that speech learning continues throughout life, utilizing the same mechanisms that were used during L1 acquisition, SLM essentially credits differences between L1 and L2 speech learning to one's prior linguistic exposure. Thus, age is predicted to

have profound effects on learning outcomes. Previous linguistic contact from L1 acquisition shapes the perception of L2 sounds, especially so if that particular L2 phone is similar to a previously experienced sound in an existing L1 category, in which case the L2 learner will undergo some effect of the equivalence classification, affecting the learning outcome. Under these circumstances, as discussed earlier, equivalence classification will in due course cause perceptual linkage of the L1 and emerging L2 sounds to the same category and limit the level of accuracy with which L2 sounds can be produced. The same circumstances will apply to those L2 sounds considered new, since even if new L2 sounds merit a formation of their own separate categories, these formations will still be affected by existing L1 representations. This is particularly so because such contrasting L1 and L2 sounds will experience exaggerated dissimilation and will, as a result, aim to maximize the observed contrast within a mutual phonological system. Therefore, and herein lies the crucial point: converging effects on L1 and L2 phones corresponding to the same category are also predicted to affect the production of L1 sounds as well, which underscores the potential for any consequential effects of a developing L2 sound system to be directed both ways. This is particularly important since the effects on L1 are often neglected as the main focus remains steady on the effects limiting proper L2 acquisition due to existing L1 representations. Likewise, divergence between L1 and L2 categories is also predicted to affect the sounds in the L1.

1.4.3 Exploring the Intersection of the PAM and SLM

In sum, the Perceptual Assimilation Model (PAM) discusses acquisition during the early stages of language learning. PAM is designed to account for ways in which native listeners, relative to their L1 phonological categories, may interpret non-native speech contrasts. Essentially, the type of perceptual assimilation that occurs with non-native contrastive pairs

predicts the level of difficulty with which learners will encounter when trying to discern between the sounds in the pair. PAM predicts that members of the contrast that are assimilated to different L1 categories will be discriminated accurately; whereas, members that are assimilated to the same L1 category will be discriminated less accurately. This model helps to acknowledge that non-native contrasts are perceived differently depending on level of ease of discriminability, rather than considering these contrasts uniformly difficult. This model is important because it explains the reasons behind the difficulty of achieving complete L2 acquisition: L1 representations, which came in first, set a precedent for incoming L2 sounds.

The Speech Learning Model (SLM), on the other hand, is based upon the belief that phonetic systems reorganize themselves in response to sounds encountered in the emerging L2. Adding new phonetic categories or modifying existing ones are ways in which phonetic systems can reorganize. The key feature of SLM is that learning mechanisms that were used during L1 acquisition are available throughout life and that, most importantly, L1 phonetic category encoding language-specific features of L1 sounds continue to develop even after childhood and well into adulthood, under the constant influence of sounds. Sounds are in flux as categories from both the L1 and the L2 coexist in a shared system. This model predicts that L1 will be influence by incoming L2 sounds because the L1 categories will be forced to readjust to these emerging L2 sounds.

While PAM emphasizes that L2 categories form in relation to the L1, placing central focus on existing L1 representations, SLM puts into context the idea that L1 categories are actually reacting to emerging L2 sounds, thus resulting in developing new categories that will help L2 acquisition or simply modifying existing L1 categories. Both seem important given that each model helps account for a different piece in the puzzle – PAM allows research to account

for pronunciation errors in the L2 and SLM explains pronunciation errors in the L1. Neither model, however, seems to account for chance of pronunciation errors simultaneously occurring in the L1 and the L2. Thus, my research is designed to build from these models, and explain the need for a new model that attempts to account for dual-directional influence, the L1 on the L2, and the L2 on the L1. I will base my research on these models to help bridge the gaps between the two.

1.4.4 Integrating Heritage Learners

As we begin to understand these various strands of L1 and L2 acquisition, it is also important to consider the role heritage learners play in this research. A heritage language is a language that is acquired by individuals who are raised in homes where the dominant language of the region, such as English in the United States, is not the language that is used. Additionally, a heritage language is typically acquired before a dominant language. However, the sounds of the heritage language are only partially acquired because the individual transitioned from the heritage language to the dominant language before complete acquisition could take place. The particular environment or context in which an L1 is acquired as a heritage language (HL) differs in many potentially profound ways from that of an L1 acquired in a conventional way, during the early stages of life through consistent exposure from birth, proceeding to constant and frequent use through life with others from the same language community. It would be predicted that such differences in environment would lead to differences in proficiency and usage of the language, however available research dedicated to the language learning process of heritage learners is limited, especially so because they are neither comparable to native speakers nor to L2 learners. In fact, it is interesting to consider the exact category in which it would be appropriate to classify heritage learners. They seem to form their own intermediate category, defined by their unique

interest in the HL though they may not demonstrate complete command of the language nor use it actively. Campbell and Rosenthal (2007) reveal in their research that the standard HL re-learners are expected to have acquired close to 90% of the phonological system of the language as well as an estimated 80% to 90% of the grammar system used in the HL, which actually demonstrates a stronger command of the HL than the level that is exhibited by second-year college L2 learners (or late L2 learners). This is especially telling as it suggests that childhood exposure with a minority language or a HL, even if the extent of which is only overhearing the language, has been noted to significantly help a speaker's phonological production and perception of that particular language when it is heard and recollected later on in life. The comparison is particularly interesting when these HL learners are compared to L2 learners who have had no prior experience with the language (Knightly, Jun, Oh, Au, 2003) and thus cannot recollect from earlier exposure in the same way HL learners are able to do so. It has been found that HL speakers tend to retain a native-like quality in their production of speech when compared to L2 speakers, especially with respect to their morphosyntax, though it is true that the HL speakers pattern differently from native speakers (Au, Oh, Knightly, Jun, Romo, 2008).

The recurring theme we see in this research is that HL speakers demonstrate a clear advantage in perception or possibly even in both perception and production, which has been attributed to having had childhood experience with the language. Au and fellow researchers have drawn a distinction between "childhood hearers" and "childhood speakers." Knightly et al. (2003) revealed from their studies that childhood hearers of Spanish, which they defined as those who had regular and consistent exposure to Spanish as hearers, but not necessarily as speakers or were even really spoken to in Spanish, were, in fact, measurably more proficient than L2 learners with the production of individual Spanish phonemes as well as collective narratives in Spanish.

Oh et al. (2003) also discovered that HL speakers of Korean had a clear phonological advantage over L2 learners. Interestingly, with this particular study, Oh et al., in addition to looking at childhood hearers of Korean, also focused on childhood hearers who spoke Korean regularly during childhood. The comparison between these groups demonstrated that while those who spoke Korean during childhood were measurably superior to L2 learners in both perception and production of Korean, childhood hearers were, however, superior to L2 learners only in perception.

This disparity in findings between Oh et al. and Knightly et al. was accounted for by a few influential factors. First, researchers noted that there was a difference in average duration of HL relearning as well as a difference in complexity between the contrasts studied. Specifically, HL relearning tends to be longer in the case of HL Spanish speakers. Furthermore, Spanish demonstrates a 2-way laryngeal contrast between voiced and voiceless stops, whereas Korean has a 3-way laryngeal contrast amongst various aspirated stops and fricatives. Therefore, Chang summarizes in his research that these findings demonstrate that "previous HL speaking experience confers an advantage in both production and perception of the HL, and that HL listening experience confers an advantage in perception of the HL. However, the benefit conferred by HL listening experience in production of the HL appears to be mediated by additional factors" (2010:61).

Heritage learners are particularly interesting, especially within the context of my research, because as Chang describes, they possess some advantage over standard L2 learners. This extends the invitation to look into ways in which this advantage may be manifested in relation to PAM and SLM. Perhaps this advantage allows for newer categories to be formed more quickly or existing ones to undergo modification more rapidly. Perhaps in the case of the

PAM, the advantage lessens the precedent set forth by L1 representations, thereby allowing heritage learners to regain command of the L2 more quickly and accurately. As said earlier, a new model needs to address both directions of influence; likewise, perhaps this advantage is conferred in both directions.

1.4.5 Language Processing for Heritage Learners

One aspect of bilingual research that is also pertinent to this paper is that of merging phonetic categories in the L1 and the L2. There has been research focusing on whether HL speakers merge different sound categories rather than producing them differently. Thus far, research has generally shown that childhood exposure is integral to adopting a more native-like quality in speech production. However, the experiences of an HL, which is typically characterized by language input that is brief, limited and often interrupted, are also insightful in studying the importance of childhood exposure to sounds in the L2 (Chang 2010). In fact, many have compared learning a language as an HL to learning an obsolescent language. The common strand that ties together the comparability of the experiences of leaning an HL and an obsolescent language is a pattern of usage of L1 that is unconventional. Essentially, in neither case do we see the L1 spoken under all communicative circumstances. Chang adds, "An HL might be spoken only at home or to older relatives, while an obsolescent language, known only by a handful of people in the community, might hardly be spoken at all. Thus, the sociolinguistic environments of these two types of languages are similar in that their usage is significantly limited" (2010). Therefore, it would be predicted to be extremely likely for cross-linguistic interference to occur. There is the possibility that the L2 can influence the L1 even under circumstances in which the L1 is completely acquired and still remains in consistent usage. Herein again, lies the significance of my study – it is important to articulate that a partially

acquired or incomplete L1, in this case Korean, is not a prerequisite needed for L1 to converge in the direction of L2. The assumption is often made that incompleteness makes a language more prone to effect, which though true at times, can, in fact, be limiting. Just as Flege described in the SLM that phonetic features of the L1 are under the influence of all sounds, even into adulthood, I would like to propose that sounds at any point of acquisition are constantly in flux, thus constantly vulnerable to influence. It is important to challenge the norms set forth surrounding our understanding of an L1. A title of permanence is too easily and too often labeled on sounds belonging to an L1. All vowels are possibly unstable.

1.4.6 Considering Age of Arrival (AOA) as Influential Factors on L1 and L2 Speech Production

Returning to our previous discussion on bilingualism as it affects L1 and L2 speech production, one of the main differences between bilinguals and monolinguals lies in their domain of production. This is especially found in instances in which bilinguals are asked to engage in tasks that motivate use of both languages. Under these circumstances, bilinguals who normally maintain a distinction between their L1 and L2 demonstrate phonetic interaction between the L1 and L2, a possible indication of the fluid nature of transitions between L1 and L2 (Bullock, Toribio, Davis, Botero, 2004). One particularly interesting finding was that early L1Korean-L2 English bilinguals produced both English and Korean with a detectable accent (Yeni-Komshian, Flege, Liu, 2000). This specific study looked at L1 and L2 production in bilinguals who varied in AOA to the US, ranging from 1-23 years of age. Native speakers of each respective language evaluated their speech production. These measurements revealed that while the L2 production of participants with the earliest AOAs proved to be significantly closer to the production of native speakers compared to participants with later AOAs, some quality of a foreign accent was still

observable. In addition, when compared to participants who had later AOAs, participants with the earliest AOAs also produced speech that was accented, even though they received ratings that were no different from those received by L1 monolinguals. When comparing measurements for L1 to L2, determining the degree to which a foreign accent was noticeable, results suggested that participants with AOAs of less than 9 years produced more native-like English than Korean, while participants with AOAs of greater than 12 years had more native-like Korean than English. More importantly, since participants with even early AOAs produced accented speech, these findings carry significant implications that perhaps any "deviations from native pronunciation result form interactions between the languages of bilinguals" (Yeni-Komshian, Flege, Liu, 2000:131), rather than from the traditionally argued viewpoint enforcing the theory of a critical period for language acquisition.

This observation that the difference in accent may be attributable to the interaction of the two languages is significant because it supports the possibility that certain linguistic phenomena are inherent to bilinguals and come about because there is a phonetic interaction between two languages. These findings help to support my proposal that a bilingual effect may be at work, essentially that some of these observed effects can be attributed to bilingualism. Additionally, these findings help corroborate the potential for phonetic drift since drift results in an assimilatory effect, which causes existing L1 vowel representations to drift in the direction of emerging L2 sounds – in other words, assimilation to L2 vowels.

The age at which the L2 is acquired and the degree to which the learner is exposed to the L2 were both found to have significant influence on the vowel production of L1 Korean-L2 English bilinguals as reported by Baker and Trofimovich's (2005). They measured 6 English vowels (/i/, /ɪ/, /ɛ/, /æ/, /u/, /ʊ/) and 5 Korean vowels (/i/, /e~ɛ/, /u/, /i/) and studied four groups of

bilinguals with varying AOAs and different levels of exposure to the language. Their findings were particularly telling, showing that while late learners did not produce Korean vowels differently from monolingual Korean speakers, their English vowels /ɪ/, /ʊ/, /æ/, on the other hand were pronounced in a manner that suggested approximation to similar Korean vowels, respectively /i, /u/, /ɛ/. Late bilinguals showed only an effect of L1 on L2, while early bilinguals' production showed influence in both directions, L1 on L2 as well as L2 on L1. Similar to late bilinguals, early bilinguals produced English vowels /ɪ/, /ʊ/, /æ/ differently from English monolinguals, in fact, in a manner indicative of English vowels converging with nearby available Korean vowels. Furthermore, bilinguals with an early AOA, but minimal previous exposure resembled late bilinguals in production of Korean vowels. They both produced Korean vowels very comparable to those produced by monolingual Korean controls. On the other hand, bilinguals with an early AOA, in addition to high levels of exposure to the language, produced the Korean vowels, /i, /u/, /ɛ/, very much differently from Korean monolinguals, in fact in a manner demonstrative of dissimilation from nearby English vowel almost as though to preserve distinct qualities in speech production and sound. These findings reinforce the possibility of L2 influence on L1, which appears to be especially favored when experience with L2 begins early and occurs with greater frequency during childhood and into adulthood.

In sum, a recurring theme in this literature is that sounds in the L1 tend to drift in the direction of the closest L2 sounds. In addition, sounds in the L1 may also drift apart from emergent L2 sounds so as to ensure maximal distance and constrast in sounds within a shared phonological system. This is also corroborated by the findings derived from Speeh Learning Model (SLM) since we find that dissimilatory effects in phonetic drift are more commonly found in early bilinguals, especially indviduals who were in contact with a developing L2 and

consequently more likely to differentiate between like sounds and establish separate phonetic categories in the L2.

It is important to consider both the assimilatory as well as the dissimilatory effects of phonetic drift. The experience of learning an L2 has the ability to influence and shape the future production of L1, which challenges the notion of static L1 categories and representations. Understandably, the potency with which the L2 affects L1 production is dependent upon whether the L1 remains an equally strong input for the bilingual speaker. The strength of an L1 could be substantially reduced in situations its use significantly diminishes in everyday communication, or, as in the case of heritage speakers and child bilinguals, the L1 was never completely acquired. If this were the case then the phonetic inventory consists of partially developed sounds. More interestingly, L1 phonetic drift can also occur in individuals who have already reached adulthood and a level of L1 proficiency comparable to that of a monolingual, prior to L2 exposure. Research on L2 learners who show high levels of L2 proficiency usually eventually results in changes in L1 production, and this happens even when use of the L1 remains consistent and frequent. How can this help to address the pronunciation errors obeserved in the L1?

1.5 Conclusion

In all, I have tried to unite the many strands that together form the collective foundation of my research. The discusison touched on the problems of a critical period and the need to reevaluate the role of the critical period in language aquisition research as the topic of shifting L1 categories becomes more and more salient. Shifting L1 categories trigger discussion about directions of influence, questioning whether only the L1 has the power to enact an effect on the L2. To lay the theoretical foundation for my ideas of dual-directionality in L1 and L2 learning and a bilingual effect, I discussed currently available models, namely the Speech Learning

Model and the Perceptual Assimilation Model, which both help to map language acquisition and discussed possible shortcomings, or ways to improve these models. Looking at ways to improve these models inspired my proposal of devising a new model that accounted for not only the effects of the L1 on L2 development, but also the effects of incoming L2 sounds on existing L1 categories.

In order to test this thesis, I recorded both English and Korean vowels of Korean-English bilinguals to determine whether emerging L2 sounds were, in fact, affecting the L1, and whether from my findings, a more comprehensive model could be drawn. It will be shown that the interactions between the L1 and the L2 demonstrate effects of influence taking place in both directions and that both the L1 and the L2 are prone to change. I also show that there might also be a bilingual effect at work, which suggests that certain processes are simply inherent to bilinguals. I propose this new model in hopes of challenging the prescribed beliefs that fully acquired categories are permanent. In the following section, I will discuss in detail the method of my study as well as descriptions of my informants. In sum, my study supports aspects of PAM, SLM, and phonetic drift, however my data leads me to argue that there are interactions of the L1 on the L2 as well as the L2 on the L1 regardless of the state of multilingualism.

CHAPTER 2 – METHOD

2.1 Subjects

Eleven women from Wellesley College participated as informants. Each informant was of Korean descent with a mean age of 20.7 years (range = 19-22), who each varied in length of residency in the US and in Korea (amongst other countries), as well as in age of arrival to the US. Thus, depending on the aforementioned variables, each informant demonstrated different levels of proficiency in Korean. Informants also differed in terms of their social and family upbringing, experiencing various dynamics in these social settings, which thus affects the development of their language and cultural identities. Depending on their background, certain informants had previously studied in Korea though all informants had studied in the US prior to arrival at Wellesley. They were all born to predominantly Korean speaking parents; though depending on the specific informant, English is currently used more often in the home. All informants reported having normal hearing. Informants were administered a questionnaire to help gather background information. See Appendix A for a reproduction of the questionnaire.

Based on their responses to the questionnaire, the eleven informants, labeled A-K, were categorized into one of four groups, which differed primarily according to language background and proficiency in Korean and English, upbringing and the types of social communities with which the informant specifically identified. As described earlier, bilingualism follows a spectrum. Each of the following groups comprises some variation of Korean and English bilinguals. Some demonstrate higher proficiency in Korean while showing traces of accented English, as others show a different combination of language ability, perhaps accented Korean with a stronger command for English. Regardless, they are all bilinguals nonetheless. The following will describe in detail the overall background of each group. Categorizing each

informant allows us to see overarching patterns while affording us the opportunity to see whether such phenomena are simply inherent to having a bilingual background or whether in fact other factors, both linguistic and non-linguistic, are at play.

Group 1 consists of a Korean and English bilingual who demonstrates high proficiency in and a strong command of both Korean and English. This informant was chosen to serve as the experimental control and to help provide an estimate of phonetic norms for Korean and English within the context of the experiment.[7] This was especially useful when mapping vowels to measure proximity between respective sets of vowels in each language. The control was born in Seoul, South Korea and predominantly raised in Korea for most of early childhood, and then moved to the US and lived in the States for the remainder of childhood and all of adolescence. The native language for both her mother and father is Korean and Korean is used in the home with family, while English is also used as often, though more so in academic settings. English is also used oftentimes with friends unless they are also of Korean descent and can use Korean proficiently, in which case Korean may also be comfortably used as the predominant mode of communication. The control has been partially educated in Korea and has studied the Korean language formally to a certain extent.

Group 2 consists of Korean and English bilinguals who show fluency in English and consider English their L1 and Korean their L2. They show a working understanding of the language though they consider pronunciation of certain sounds and general L2 production to be challenging, hence producing Korean with heavy traces of a foreign accent. They were born and

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[7] An actual set of measured phonetic norms for both Korean and English was used for more formal and comparative analysis, which will be elaborated on in the following section after the presentation of our findings. Within this particular context of our experimental control, mapping these informants' English and Korean vowels allowed us to see the shape of their vowels, and create a phonetic norm relative to our other informants since, presumably the informant in Group 1 would display a certain curvature in their vowel placement comparable to the shape demonstrated by monolingual speaker of English and monolingual speakers of Korean.

raised in the US, and have rarely been to Korea, save on trips for about 1-3 months, at the most. These informants use predominantly English in the home as well as in social settings, even if they are with others who are also of Korean descent and may be able to communicate in Korean. In the home, specifically, though the mother and father of the informants consider Korean to be their L1, they communicate more often in English to their daughters, the informants. Or in other cases, informants address their immediate family in English, while the family members respond in Korean, which is noteworthy since while the informants themselves are not actively speaking the language and exercising Korean, they do still, receive a significant amount of Korean input. They may have been exposed to Korean at an early age and for a few years during early childhood, but quickly transitioned to English thereafter, which eventually became the L1.

The point of transitioning from Korean and English usually occurred between 2-4 years of age for all informants in this category. At this point it is most often the case that Korean is no longer their first language and the language is no longer used nearly as frequently as it was before the transition; hence many of the sounds in the Korean language that were once native have become foreign, and are lost or almost forgotten. Now as young adults, they are undergoing a resurgence of Korean as they hear it more often amongst friends who identify with the Korean and Korean-American communities and informants become more accustomed to sounds as they hear it through pop culture and various social outlets and mediums. These informants have also only attended school in the US and thus, have only been taught in English. They may have taken a class in elementary Korean, but have never been educated in the language directly.

Group 3 consists of Korean and English bilinguals who demonstrate fluency in Korean and consider English, relative to their high proficiency in Korean, their L2. Given that these informants were born in Korea and have had prior residency in the country, they consider Korean

their L1. Many of these informants are also those who have had experience attending international schools, which potentially have an effect on their speech production since many of these international schools engage in bilingual instruction. In addition to international school, they have also received formal instruction in Korean and have attended school in Korea. Though their level of proficiency in English is relatively high, their English speech is still characterized by a noticeable foreign accent. They predominantly use Korean in everyday interactions, whether in the home or with social groups, unless English is required such as in the classroom setting or with English-speaking friends. Korean is the native language for both their mothers and fathers.

Finally, Group 4 consists of informants who demonstrate a working understanding of both English and Korean, but in neither language has the informant achieved complete mastery. Some of the informants in Group 4 were either born in Korean and moved to the US at an early age while others were both born and raised in the US. Regardless of their place of birth, Korean was the first language used in the home, initially making it their L1. However, many of the families of these informants immigrated to the States, and as a result they were forced to learn English, still at an early point in childhood. Usually, informants in Group 4 were asked to translate for families, since both the mother and father are only able to communicate in their L1, which is Korean. These informants were educated in English in US schools. Many of these informants have also studied Korean formally in a classroom setting. Typically, these informants use Korean in the home, while they use both Korean and English in social settings, and English in the classroom. Thus, the medium of their everyday conversations with friends and social groups, and oftentimes with family as well, changes from English to Korean and from Korean to English.

One particularly noteworthy aspect of the informants in Group 4[8] is that they represent, in many ways, an intersection of Groups 2 and 3, producing almost a hybrid of informants from both groups. Informants in Group 4 show a working knowledge of both Korean and English, though they fall short of the level of command my informant in Group 1 demonstrate. While they have relatively high proficiency in both languages, they show complete mastery in neither one, thus making it difficult to deem one language as the L1 over the other. Thus, there are noticeable foreign accents in the production of both English and Korean, most likely indicative of the possibility that sounds in both phonetic systems of English and Korean are partially developed. This is largely due in part to their upbringing in immigrant families. Even though Korean was originally their L1, because the move took place early during the childhood years, Korean is only partially their L1 because the move occurred before a set of L1 representations and a complete sound system could be formed. Thus, with partially developed sounds in Korean in tow, these informants moved to the US or similar to Group 2, were placed under circumstances to learn English, at which English also became a comparable rival for the role of the L1, though still their L2 in many ways. Effectively, those from immigrant families had to use English in order to serve as translators or function in some capacity as liaisons of communication for their families. Therefore, emerging English phonemes were quickly put into immediate contact with also still developing Korean phones.

As for my other informants in this same category who were born and raised in the US, they, too, descend from immigrant families. However, unlike the informants in Group 2, their

[8] It should be noted that all of my informants contribute to my research in a meaningful way and that each group of informants presents interesting findings that are explored in Chapter 4.

Korean was never completely forgotten.[9] Rather it is used in the home very frequently. English, however, is also used frequently outside the home, as is Korean should they be with friends or people who identify with the Korean and Korean-American communities. While afforded the opportunity to speak both languages, both are produced with detectable foreign accents. These informants were educated in the US in English-medium schools, though they still may have attended formal classes to learn Korean. Therefore, I was curious to study these informants because it seems that they adopted neither one as their "true" L1 as evident by the foreign accent detected in the production of both English and Korean. As I will discuss in Chapter 4, the interaction between Korean and English as they came into contact during development proves to have some interesting consequences. Table 1 summarizes each as previously described.

Group 1: The Control	Fluent Korean and English
Group 2	Non-fluent in Korean, fluent in English
Group 3	Fluent in Korean, non-fluent in English
Group 4	Non-fluent in English and Korean

TABLE 1. Summary of group backgrounds.

2.2 Procedure

Each of the informants was asked to read the one English passage and one Korean passage (given below in **2.3 Stimuli**) in order to elicit the target English and Korean vowel sounds. Because all the informants varied in terms of proficiency in Korean, each individual read

[9] It is very important to bear in mind the dichotomy between Groups 2 and 4. Though informants from each set may seem similar in family upbringing, the most critical difference to consider is that while Groups 2 and 4 may have started their language identity with Korean as their L1 and transitioned to English at some point, Korean remained a form of an L1 for informants in Group 4, whereas, informants in Group 2 consider English their L1 after undergoing the language shift, and Korean their L2. In other words the definition of an L1 is more complicated for our informants in Group 4, as it seems to be shared by Korean and English to some extent.
Note: As was mentioned in Chapter 1 and will be discussed again in greater detail in the following sections, informants of both Groups 2 and 4 are, in fact, some variation of heritage learners.

some combination of the four passages. I used the results from the assessments to determining fluency to help gauge the level of difficulty that would be appropriate for their passage selection. While everyone read both English passages, not everyone read both Korean passages presented in the following section because the passage given in (1) is slightly more suited for beginners than is the passage in (2) which is more difficult. Thus, depending on the passage read, and unless both passages were read because they were able to do so, certain informants lack formant measurements for the /ɨ/, /y/ or /ø/ vowels in Korean. This does not affect our findings, as I was able to capture all other vowels, especially the cardinal ones in each language. This only really affects the average formant values for each vowel that was calculated, but this was accounted for by adjusting the number of informants to the number of informants who had actually recorded that sound. Thus, rather than using 11 in our calculation, I used the changed total number of informants accordingly depending on the number of recorded informants for that particular Korean vowel.

The production of each vowel for both English and Korean was measured in the same phonetic environment for all informants for purposes of consistency. These environments will be highlighted in Table 2. While the English passages that were used are ones commonly used to evaluate speech production, a comparable one could not be found in Korean and was thus independently designed for the specific use of this research. The English passages were designed to use words that sample a diverse range of possible vowel and consonant sounds in English. The Korean passage was designed with the same goal in mind, however it is also important to keep in mind possible shortcomings and limitations in producing comparable quality in these passages. That said, the following target vowels were measured in English: /ɪ, u, i, ʊ, a, e, o, ə, æ, ʌ, ɛ/, and the following vowels in Korean: /y, u, i, ʊ, a, e, o, ə, æ, ɨ, ɛ, ø/.

Native speakers of Korean and English independently assessed whether informants demonstrated a strong command for that specific language. Native speakers of English were played recordings of each informant speaking English and based upon their perceptions, were rated on a Likert scale of 1-5 accordingly to determine, or at least, quantify, their level of fluency. These assessments were based solely on speech production. Similarly, native speakers of Korean were played recordings of each informant speaking Korean and based upon their perceptions, were asked to evaluate each informant by assigning a rating on a Likert scale of 1-5.[10] Likewise, these evaluations were based solely on their ability to produce Korean and did not take into consideration their ability to read or write in Korean.[11] Though their ability to read was partially sampled in the recording since they were asked to read, I did not take into consideration the speed or the comfort with which they read the Korean passages as any indicators for fluency; I only looked at speech production and the independent assessors were instructed to only consider speech production. These results will be presented in Chapter 3, first by informant and then a collective average will also be calculated based on groups. That way, groups can also be looked at from the perspective of the overall rating determining fluency.

2.3 Stimuli

This section provides all the passages that were used to record the informants producing all the target vowel sounds in both languages. As mentioned earlier, while everyone read both of the English passages, depending on the informant's level of proficiency in Korean, she read

[10] The exact rating scale will be discussed in Chapter 3 alongside the results.

[11] Oftentimes, Korean-English bilinguals or heritage learners of Korean demonstrate high levels of proficiency in their spoken Korean and are perceived by others to fluent even though they may not demonstrate the same level of high proficiency in reading and writing Korean. Thus it should be clarified that for the purposes of my research, I did not sample reading or writing abilities, and therefore my definition of fluency for this research is based only on speech production.

either one of the two given passages according to level of difficulty, or she read both because she was able to, and thus I was able to sample all of the Korean vowels for those informants.

1) The first English passage used to elicit the production of English vowels.

The Grandfather Passage[12]

You wished to know all about my grandfather. Well, he is nearly ninety-three years old; he dresses himself in an ancient black frock coat, usually minus several buttons; yet he still thinks as swiftly as ever. A long, flowing beard clings to his chin, giving those who observe him a pronounced feeling of the utmost respect. When he speaks, his voice is just a bit cracked and quivers a trifle. Twice each day he plays skillfully and with zest upon our small organ. Except in the winter when the ooze or snow or ice prevents, he slowly takes a short walk in the open air each day. We have often urged him to walk more and smoke less, but he always answers, "Banana oil!" Grandfather likes to be modern in his language.

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2) The second English passage used to elicit the production of English vowels

The Rainbow Passage

When the sunlight strikes raindrops in the air, they act as a prism and form a rainbow. The rainbow is a division of white light into many beautiful colors. These take the shape of a long round arch, with its path high above, and its two ends apparently beyond the horizon. There is, according to legend, a boiling pot of gold at one end. People look, but no one ever finds it. When a man looks for something beyond his reach, his friends say he is looking for the pot of gold at the end of the rainbow.

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[12] Developed from Fairbanks, G. (1960). *Voice and articulation drillbook*. (2 ed., 127). New York, NY: Harper & Row.

3) The first Korean passage used to elicit the production of Korean vowels, followed by an English translation.

새 친구 이야기

아름다운 골짜기에 예쁜 2층 집이 있어요.

이 집에는 누가 살고 있을까요?

1층에는 깔끔한 멋쟁이 검은 고양이가 살아요.

고양이는 언제나 목에 멋진 리본을 묶고 있어요

2층에는 다람쥐가 살고 있어요.

다람쥐는 하루 종일 호두만 까 먹고 있지요.

Story of New Friend

There is a lovely two-story house in a beautiful valley

Who is living in this house?

A gentle clean black cat is living on the first floor.

The cat is always wearing cute ribbon on its neck.

A squirrel is living on the second floor.

The squirrel is eating nuts all day long.

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4) The fourth Korean passages used to elicit the production of Korean vowels, followed by an English translation.

커다란 악어 이야기

옛날에 아주 커다란 악어가 아주 작은 아들과 살았습니다.

커다란 악어는 힘이 무척 세고, 사납고 잔인했습니다.

욕심이 많은데다가, 고약한 냄새도 났습니다.

그리고 몸집은 코끼리 두마리를 합진 것보다 더 커다랬습니다.

이 커다란 악어는 강가에 살고 있는 마흔다섯 마리 동물들의 왕이었습니다.

커다란 악어는 세상의 동물들을 모조리 먹어치우고 싶었습니다.

무엇보다도 새가 가장 맛있을 것 같았습니다.

그러나 아직까지 새를 한번도 잡아 보지 못했습니다.

작은 악어는 언제나 쾌활하고 기분이 좋았습니다.

작은 악어는 하루 종일 풀밭에 벌렁 드러누워 햇볕을 쬐며 즐거워했습니다.

Story of a Big Crocodile

A long time ago, a big crocodile lived with a little son.

The big crocodile was strong, fierce and brutal.

The crocodile was greedy and had a bed smell.

Its body was bigger than two elephants combined.

This crocodile was the king of forty five animals living along the riverside.

The crocodile wanted to eat every animal in the world.

The crocodile thought that birds would be the most delicious.

The little crocodile was always bright and happy.

The little crocodile laid on the grass and enjoyed the sun all day long.

TABLE 2. The specific words used to elicit the production of the vowel sounds in each language.

English			Korean		
1. /ɪ/	him	/hɪm/	1.	/o/	요
2. /i/	each	/iːtʃ/	2.	/u/	우
3. /u/	ooze	/uːz/	3.	/ə/	어
4. /a/	banana	/bəˈnɑːnə/	4.	/i/	이
5. /e/	take	/tek/	5.	/e/	에
6. /ə/	according	/əkɔrdɪŋ/	6.	/a/	아
7. /æ/	grandfather	/grændfɑðər/	7.	/ɛ/	예
8. /ʌ/	but	/bʌt/	8.	/ɨ/	은
9. /ɛ/	dresses	/drɛsəz/	9.	/ø/	쬐
10. /o/	smoke	/smok/	10.	/y/	쥐
11. /ʊ/	look	/lʊk/			

2.4 Measurement of Vowels in Korean and English

The speech material was recorded on PRAAT (Boersma & Weenink, 2011) in a soundproof lab at Wellesley College. Each informant was recorded individually in the lab, reading some combination of the four passages. In all, I recorded and listened for 11 English vowels and about 8-10 Korean vowels, depending on the Korean passage that was read, for each of the 11 informants, which amounted to a total of around 220 vowels. However, because occasionally, the recorded sound was too embedded in neighboring sounds and difficult to discern, I had to listen to other instances of the particular vowel to ensure that my measurements were consisted, which demonstrates that I studied close to 300 vowels.

I chose to study vowels because they offer the most amount of variability in pronunciation depending on the phonotactic constraints that are available in a given language, and since English and Korean, while still sharing many overlapping vowels, are different enough

from one another, I proposed studying vowels to be an interesting way to study pronunciation errors in both languages. The recorded speech material was then studied on PRAAT, looking specifically at spectrograms to measure formant values for each vowel produced in both languages. Once locating the specific vowel sound I needed, in order to see the spectrogram more closely at that specific point, I cut out the vowel segment from the larger sentence. Thus, in addition to listening for 300 vowels, I also cut out 300 vowel sounds from the recordings.

Following is a brief description of vowels and vowel features, formants and the importance of spectrograms. Vowel sounds can be articulated on a variety of notes, or voice pitches. Ladefoged (2006) describes that there are two notable characteristic vocal tract pitches associated with their vowels tones that helps to differentiate one vowel from another. One of these features corresponds to the difference between front and back vowels. The other is low for vowels in which the position of the tongue is high and high for vowels in which the position of the tongue is low. This corresponds inversely to a feature of vowels that is normally known as vowel height in articulatory terms. These characteristic overtones form the basis of vowel formants and are used to help distinguish one vowel from another. The first formant (F1) is characterized by a lower pitch, which is most noticeable in creaky voice, and the higher one the second formant (F2), which is most observed when whispering. Though there are higher formants such as F3, F4, F5, and I do measure the F3 values for all the vowels recorded, I only use F1 and F2 for calculations and other such analyses. Generally, F3 measurements are most pertinent when discussing r-colored[13] vowels since it is often noted that these vowels lower the F3 measurements. It is typically standard to measure the first three formants (F1-F3). In sum,

[13] R-colored vowels, or also known as rhotic vowels, are vowels articulated one of the following ways; either the tip or blade of the tongue is turned upward during at least part of the articulation of the vowel, as is the case in retroflex articulation, or the back of the tongue is bunched together. Another notable aspect in rhotic vowel articulation is the constriction of the vocal tract in the epiglottis region.

Ladefoged (2006) discusses that there are three main features of vowel quality, the first is vowel height, which is inversely proportional to the frequency of the first formant, the second backness, which is proportional to the difference between the frequencies of the first and second formants, and third, the degree of lip rounding, which typically lowers both the second and third formants.

In addition to formants, spectrograms are also useful in helping to capture important features of vowels. When the recorded vowels were run through PRAAT, the program was able to analyze the sounds and display their components. This display that is generated is known as a spectrogram. To explain spectrograms, time elapses from left to right, the frequency of the components is shown on the vertical scale, and the intensity of each component is marked by degrees of darkness (Ladefoged, 2006). The captured display essentially depicts dark bands for concentrations of energy at specific frequencies, which helps to convey the source and filter characteristics of speech. Figures 1 and 2 give examples of spectrograms

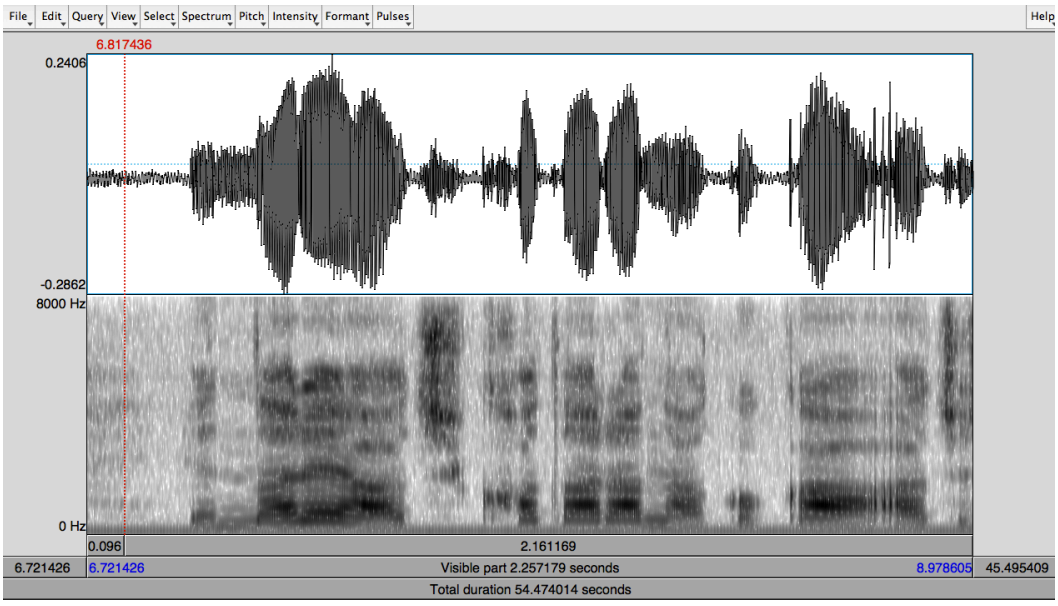

FIGURE 1. Example of a spectrogram

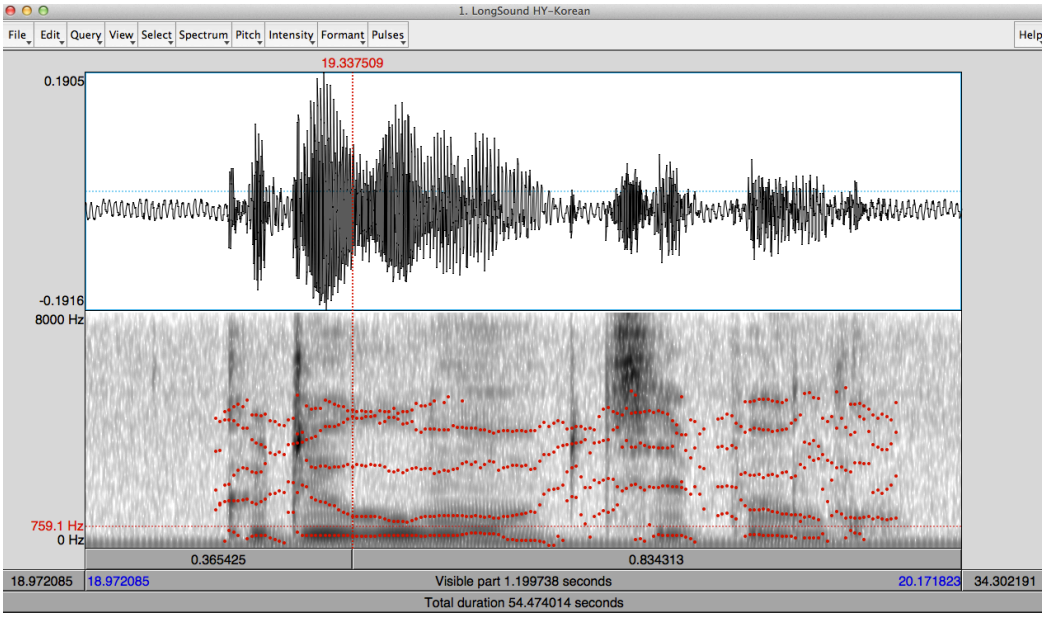

FIGURE 2. Example of spectrogram in which the formants are shown in red. Each concentrated horizontal striation represents a formant.

For consistency, each formant was measured from below, as is demonstrated in Figure 2. This procedure was repeated for each informant, and for every informant, the first three formants for each elicited vowel in English and Korean were measured, where the horizontal dashed line in red measures the (F2) at 759.1 Hz. The measurements were then recorded and used to create formant charts, which reflect the acoustic measurements of the vowels. These charts show the precise locations of vowels in relation to other vowels. As is standard practice when mapping vowels (Hayward, 2000; Ladefoged, 2006), I placed the first formant values along the y-axis, and the second formant measurements along the x-axis, using the intersection of the first and second formants to plot points. This method of plotting the F1 value against the F2 value[14] because it is able to show vowel quality in a variety of different languages (Hayward 2000).

[14] Originally, vowel charts were created by plotting the F1 measurements against the difference of the first and second formants (F2-F1), and this method was also used by Ladefoged (2006), but in later editions of his textbook (2011), he, too, began to adopt the current convention of plotting the F1 against the F2. Hayward explains that the first method is problematic because of its effects on the placement of central vowels (2000).

I also used a set of phonetic norms for Korean and English vowels (Yang 1996),[15] or average values, which, for the purposes of my research, I took to be standard values, to compare the vowel measurements my informants produced. For each informant, I prepared two separate vowel charts, one representing her English vowels, and another representing her Korean vowels. Then, I also produced another formant chart that depicted both sets of vowels on one map. Using the phonetic norms, I prepared two additional formant charts, one depicting the informant's English vowels mapped on top of the standard formant values for English vowels, and another depicting the informant's Korean vowels on top of standard measurements for Korean vowels. In all, a set of 5 separate formant charts were produced for each informant; thus 55 charts in total.

Finally, using a standard deviation,[16] we were also able to calculate the exact value by which our informants were deviating from the phonetic norm. This was especially useful when discussing vowel proximity between English and Korean vowels. The following chapter will provide all the formant measurements that were collected in this study, along with a brief description of each corresponding informant.

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[15] These measurements refer to the research done by Yang (1996) when he collected the formant values of 10 male and 10 female speakers of each language, Korean and English. With his findings, he was able to produce average values for each formant for each English and Korean vowel. Later the analysis will build upon Yang's average values to draw comparative analysis.

[16] Similarly, the standard deviations were given in Yang's (1996) research, which are based upon his own findings.

CHAPTER 3 – DATA COLLECTION

The following section will present the first three formant (F1-F3) measurements for each of the informant's English and Korean vowels. The measurements are prefaced by a brief description of the informant. There will be unavailable measurements for certain Korean vowels; as articulated earlier, this is because depending on the Korean passage the informant read, that particular sound was not sampled in that specific passage. This section will also present the results from the independent assessments used to determine the level of fluency of each informant. These results will be particularly important in Chapter 4 when analysis will include discussion of each informant's level of proficiency in both English and Korean.

3.1 Informant A

Informant A was born in Los Angeles, California and has been residing in the US for 20 years. Korean is the native language for both her mother and father. She has studied Korean at Wellesley, completing KOR 101 and 102. Korean was the first language used in the home. She is a member of Group 2.

TABLE 3. Measurements of the first three formants (F1, F2, F3) of English vowels for Informant A

Vowel	F1	F2	F3
ɪ	516	906	1957
u	289	1607	2451
i	556	2410	3048
ʊ	474	1092	2780
a	618	1113	2018
ɛ	433	1380	2471
ʌ	371	1277	2842
æ	433	1710	2410
ə	412	1360	2554
e	392	2224	2677
o	433	906	2410

TABLE 4. Measurements of the first three formants (F1, F2, F3) of Korean vowels for Informant A

Vowel	F1	F2	F3
e	495	1545	2760
ɛ	474	1627	2762
a	989	1380	3109
o	453	1133	2636
u	330	1154	2430
ə	536	1010	2904
i	412	2574	2965
y	474	1607	2904
ɨ	495	1216	2718
ø	412	1092	2574

3.2 Informant B

Informant B was born in Salt Lake City, Utah and has been residing in the US for about 21 years. Korean is the native language for both her mother and father. She has previously visited Korea, for a combined duration of about 8 months. She has been studying Korean at Wellesley for about 3 years, completing KOR 101-2, KOR 201-2 and KOR 231-2. English was her first language in the home. She is a member of Group 4.

TABLE 5. Measurements of the first three formants (F1, F2, F3) of English vowels for Informant B

Vowel	F1	F2	F3
ɪ	453	1689	2512
u	227	1277	2595
i	289	2018	2698
ʊ	453	1298	2533
a	577	1401	2739
ɛ	453	1339	1813
ʌ	453	1648	2512
æ	536	1401	2677
ə	412	1586	2657
e	248	1401	2615
o	566	1030	2698

TABLE 6. Measurements of the first three formants (F1, F2, F3) of Korean vowels for Informant B

Vowel	F1	F2	F3
e	556	1854	2657
ɛ	433	1689	2533
a	639	1339	1977
o	350	1833	2451
u	289	845	2677
ə	433	968	1833
i	248	2657	2854
y			
ɨ	392	1545	2245
ø	474	1483	2883

3.3 Informant C

Informant C was born in Monterey, California, but was raised in Seoul, South Korea, Moscow, Russia, and Kazakhstan. Korean is her native language and she has been residing in the US for 5 years. Korean is the native language for both her mother and father. She was educated in Korea for elementary school as well as for 2 years in high school. Korean was her first language used at home. She is a member of Group 3.

TABLE 7. Measurements of the first three formants (F1, F2, F3) of English vowels for Informant C

Vowel	F1	F2	F3
ɪ	453	1710	2821
u	474	989	2512
i	289	1833	2492
ʊ	289	742	2636
a	536	1380	3418
ɛ	206	1463	3048
ʌ	371	1442	2657
æ	598	1566	2574
ə	412	1318	2327
e	268	1833	2657
o	495	865	3439

TABLE 8. Measurements of the first three formants (F1, F2, F3) of Korean vowels for Informant C

Vowel	F1	F2	F3
e	453	1689	2821
ɛ	536	1524	2986
a	536	1421	2698
o	309	1257	2512
u	330	947	1504
ə	391	906	3007
i	330	2183	2718
y			
ɨ	556	1442	2739
ø	330	1545	2615

3.4 Informant D

Informant D was born in Seoul, South Korea and was raised in Seoul for her first 4 years. Since then, she has been residing in the US for 18 years. Korean is the native language for both her mother and father. Since leaving Korea, she has never returned to visit the country. She has taken several Korean classes at Wellesley. Korean was the first language used in the home. She is a member of Group 4.

TABLE 9. Measurements of the first three formants (F1, F2, F3) of English vowels for Informant D

Vowel	F1	F2	F3
ɪ	350	1463	2698
u	309	947	2512
i	248	2451	2945
ʊ	330	803	2821
a	453	1463	2224
ɛ	474	1442	2327
ʌ	371	1524	2883
æ	474	1442	2163
ə	474	1298	2224
e	330	1463	2986
o	330	845	2818

TABLE 10. Measurements of the first three formants (F1, F2, F3) of Korean vowels for Informant D

Vowel	F1	F2	F3
e	392	1483	2965
ɛ	433	2039	2986
a	659	1421	2307
o	433	1380	2389
u	309	886	2574
ə	350	721	2780
i	474	2862	3398
y	309	1524	2677
ɨ	495	1380	2451
ø	371	1689	2636

3.5 Informant E

Informant E was born and raised in Seoul, South Korea, though she has also lived in Singapore for 3 years and Virginia for about 2-3 years. Korean is the native language for both her father and mother. Korean was the first language used in the home. She is a member of Group 1.

TABLE 11. Measurements of the first three formants (F1, F2, F3) of English vowels for Informant E

Vowel	F1	F2	F3
ɪ	536	1792	2760
u	227	947	2492
i	371	2595	3068
ʊ	495	1257	2471
a	598	1071	1792
ɛ	433	1524	2224
ʌ	392	1216	2574
æ	453	1380	2018
ə	392	1442	2698
e	433	1915	2821
o	515	1174	2760

TABLE 12. Measurements of the first three formants (F1, F2, F3) of Korean vowels for Informant E

Vowel	F1	F2	F3
e	577	1545	1998
ɛ	474	1545	2862
a	680	1360	2554
o	268	1566	2204
u	412	1113	2595
ə	412	927	2574
i	265	2505	3295
y			
ɨ	474	1483	2821
ø	433	1751	2718

3.6 Informant F

Informant F was born and raised in New York City, New York. She was educated in the US and has only visited Korea for a period of 3 months. Korean is the native language for both her father and mother. English was the first language used in the home. She is a member of Group 2.

TABLE 13. Measurements of the first three formants (F1, F2, F3) of English vowels for Informant F

Vowel	F1	F2	F3
ɪ	474	1586	2204
u	268	989	2268
i	286	2274	2682
ʊ	350	886	2410
a	515	1607	2286
ɛ	453	1483	2204
ʌ	289	1504	2512
æ	495	1421	2286
ə	536	1339	2883
e	566	1874	2718
o	433	1318	2204

TABLE 14. Measurements of the first three formants (F1, F2, F3) of Korean vowels for Informant F

Vowel	F1	F2	F3
e	412	1442	2821
ɛ	433	1360	2471
a	515	1524	2451
o	330	1442	2286
u	474	1051	2265
ə	515	1360	2245
i	474	2348	3068
y	474	2183	2821
ɨ	309	1442	2780
ø			

3.7 Informant G

Informant G was born in Seoul, South Korea, but moved to the US at the age of 5 and has been residing in the US for about 15 years. Korean is the native language for both her mother and father. Since then, she has returned to Korea once for about a month. When in elementary school, she participated in an after school program called JEI which allowed her to formally learn Korean for about 3 years. She has also previously studied Korean at Wellesley, completing KOR 231. Korean was the first language used in the home. She is a member of Group 4.

TABLE 15. Measurements of the first three formants (F1, F2, F3) of English vowels for Informant G

Vowel	F1	F2	F3
ɪ	371	1421	2265
u	371	947	2348
i	350	2018	2862
ʊ	350	1133	2739
a	474	1483	2307
ɛ	474	1442	2121
ʌ	495	1380	2183
æ	783	1463	2286
ə	474	1439	2379
e	350	2060	2636
o	350	824	2142

TABLE 16. Measurements of the first three formants (F1, F2, F3) of Korean vowels for Informant G

Vowel	F1	F2	F3
e	577	1524	2821
ɛ	433	1442	2821
a	845	1380	2265
o	371	906	2389
u	392	1216	2245
ə	392	803	2224
i	412	2101	2842
y ɨ	415	1698	2718
ø	474	1339	2739

3.8 Informant H

Informant H was born in Seoul, South Korea and was raised in Seoul for her early childhood. When she was 13, she moved to Deerfield, Massachusetts. Since then, she has been residing in the US for about 9 years. Korean is the native language of both her mother and father. Korean was the first language used in the home. She is a member of Group 4.

TABLE 17. Measurements of the first three formants (F1, F2, F3) of English vowels for Informant H

Vowel	F1	F2	F3
ɪ	412	1504	2224
u	330	865	2204
i	330	2142	2636
ʊ	577	927	2698
a	495	1813	2842
ɛ	392	1771	2636
ʌ	350	906	2204
æ	598	1627	2657
ə	433	927	2060
e	309	2121	2883
o	515	865	2751

TABLE 18. Measurements of the first three formants (F1, F2, F3) of Korean vowels for Informant H

Vowel	F1	F2	F3
e	412	1936	2801
ɛ	721	1813	2883
a	742	1442	2142
o	289	762	2286
u	453	865	2615
ə	474	927	2492
i	639	2595	3830
y			
ɨ	289	1504	2368
ø	289	1792	2739

3.9 Informant I

Informant I was born in Seoul, South Korea and lived in Korea for about 3 years. She then moved to Dallas, Texas, where she was raised and has been residing in the US for about 18 years. Korean is the native language of both her mother and father. She has previously visited Korea, for a combined duration of 3 months. She has studied Korean at Wellesley, completing KOR 309. Korean was the first language used in the home. She is a member of Group 4.

TABLE 19. Measurements of the first three formants (F1, F2, F3) of English vowels for Informant I

Vowel	F1	F2	F3
ɪ	618	1607	2595
u	309	824	2471
i	371	2533	3036
ʊ	433	1257	2471
a	639	1648	2965
ɛ	556	1545	2760
ʌ	309	1524	2430
æ	618	1627	2471
ə	495	1504	2327
e	371	1874	2451
o	350	824	2492

TABLE 20. Measurements of the first three formants (F1, F2, F3) of Korean vowels for Informant I

Vowel	F1	F2	F3
e	536	2183	2883
ɛ	474	1524	2760
a	906	1504	2657
o	289	865	2163
u	309	1010	2389
ə	268	803	2718
i	289	2615	2956
y			
ɨ	268	1421	2615
ø	371	1710	2389

3.10 Informant J

Informant J was born in Redmond, Washington and has been residing in the US for 19 years. Korean is the native language of both her mother and father. She has never previously visited Korea and has never formally learned Korean. English was the first language used in the home. She is a member of Group 2.

TABLE 21. Measurements of the first three formants (F1, F2, F3) of English vowels for Informant J

Vowel	F1	F2	F3
ɪ	433	1566	2801
u	289	1401	2245
i	330	2327	3718
ʊ	495	927	2410
a	412	1504	2245
ɛ	474	1401	2327
ʌ	350	1318	2204
æ	680	1442	2348
ə	350	1421	2245
e	330	222	2671
o	453	886	2265

TABLE 22. Measurements of the first three formants (F1, F2, F3) of Korean vowels for Informant J

Vowel	F1	F2	F3
e	289	1883	2657
ɛ	453	1710	2636
a	536	1339	2451
o	392	1133	2286
u	453	1401	2657
ə	566	1193	2533
i	289	2101	2842
y	268	1318	2060
ɨ	392	1566	2512
ø			

3.11 Informant K

Informant K was born and raised in Seoul, South Korea. When she was 10, she moved to Auckland, New Zealand, and lived there for about 2 years. Afterwards, from ages 12-18, she lived in Singapore and since then has been residing in the States. Korean is the native language of both her mother and father. She has studied Korean at Wellesley, completing KOR 231. Korean was the first language used in the home. She is a member of Group 3.

TABLE 23. Measurements of the first three formants (F1, F2, F3) of English vowels for Informant K

Vowel	F1	F2	F3
ɪ	433	1854	2389
u	206	1030	2492
i	515	1380	2183
ʊ	474	1216	2533
a	556	2101	2904
ɛ	412	1257	2183
ʌ	412	1257	2245
æ	556	1504	2204
ə	577	1133	2080
e	371	2142	2744
o	330	1092	2163

TABLE 24. Measurements of the first three formants (F1, F2, F3) of Korean vowels for Informant K

Vowel	F1	F2	F3
e	495	1216	2245
ɛ	515	1566	2451
a	536	1133	2368
o	309	947	2368
u	289	947	2368
ə	453	947	2224
i	289	2410	2986
y ɨ	433	1550	2781
ø	474	1195	2587

3.12 Determining Levels of Fluency in English and Korean

Table 25 gives the results from the independent assessments to determine levels of fluency in both Korean and English. Informants were rated on a Likert scale of 1-5 with the following scaling method – 1: Non-fluent, completely accented speech production; 2: Beginners' level proficiency, very noticeable foreign accent in speech production; 3: Intermediate level of

proficiency and conversational, foreign accent in speech production; 4: High level of proficiency and fairly advanced, almost no, but still slight foreign accent in speech production; 5: Fluent, no foreign accent in speech production. This same scaling method was used to assess both English and Korean. Then, Table 26 presents the calculated average rating of fluency in both English and Korean by each group.

TABLE 25. Results from independent assessments determining level of fluency in English and Korean by individual informant.

Informant	R1 [ENG]	R2 [KOR]	Group
A	5	2	2
B	5	3	4
C	3	5	3
D	3	3	4
E	5	5	1
F	5	1	2
G	3	4	4
H	3	5	4
I	4	5	4
J	5	1	2
K	3	5	3

TABLE 26. Averages of the ratings of all the informants categorized by group.

Group	AVG 1 [ENG]	AVG 2 [KOR]
1 [Control]	5	5
2	5	1.33
3	3	5
4	3.6	4

CHAPTER 4 – DISCUSSION

In the following sections I will discuss the data that were presented in Chapter 3. My discussion will offer the following conclusion – that pronunciation errors in the L1 are due to the formation of vowel sounds that are unique to the individual. These vowels, which I refer to as melded, result from the clustering of multiple vowels, which then collapse into one sound. I propose that vowels are clustering for one or more of the following reasons: first, that since bilingualism is on a spectrum, some bilinguals' vowels are currently clustered because these sounds have yet to be fully acquired; or second, that the introduction of new vowel categories in the L2 influence existing representations in the L1. I propose a new model that accounts for these new phenomena by suggesting that directionality can be in effect both ways – L1 on an emergent L2 as well as an emergent L2 on the existing L1. I will also introduce the bilingual effect, which suggests that certain linguistic phenomena are inherent to bilingualism. In sum, I will argue for the notion that all vowels are in a state of fluctuation and under constant influence of other emerging or changing vowels. First I will talk about the phonetic norms briefly mentioned in Chapter 2, which will help set the stage for my vowel comparisons.

4.1 Phoneme Mapping

It is important to address the specific formant values used to draw comparisons in my argument. In the following section, there will be a brief description of the research yielding the following value formant measurements, which will be considered standard values for the purposes of my study. This section will first discuss a set of standard vowel measurements from which I compare my vowel measurements. Then the section will discuss my informants in terms of the groups that were established earlier in Chapter 2. In each sub-discussion of a particular

group, I will use one informant as an exemplar from each group category that best illustrates the most notable features.

Before I proceed any further with my analysis, a few definitions are in order. When discussing vowels on formant charts, I will often describe certain vowels to be clustering or collapsing. I would like to clarify those terms now with the following diagrams. When a vowel is on top of another vowel, this indicates a collapsed vowel. When multiple vowels are located in close proximity to one another, this indicates a clustering of vowels. Sometimes, a vowel will be so densely clustered, that vowel collapsing occurs as a result; this will also be noted in my discussion. For example, in Diagram 1 below, the circled region indicates all the Korean and English vowels that have started to cluster. The square on the right indicates an instance of collapsing, where the /u/ and the /o/ are mapped slightly on top of each other. The same instance of collapsing also occurs in the region of clustering; the English vowel /ʊ/ is mapping on top of the Korean vowels /e/ and /ø/. In this particular case, these vowels have clustered so much so that they have collapsed into one another. Additionally, the arrow points to a extreme instance of collapsing, where the English vowels /ɛ/ and /ʌ/ are essentially mapped directly over one another, such that both vowels are represented by one point. Instances such as these suggest that perhaps the collapsed vowels, when produced, are the same sound.

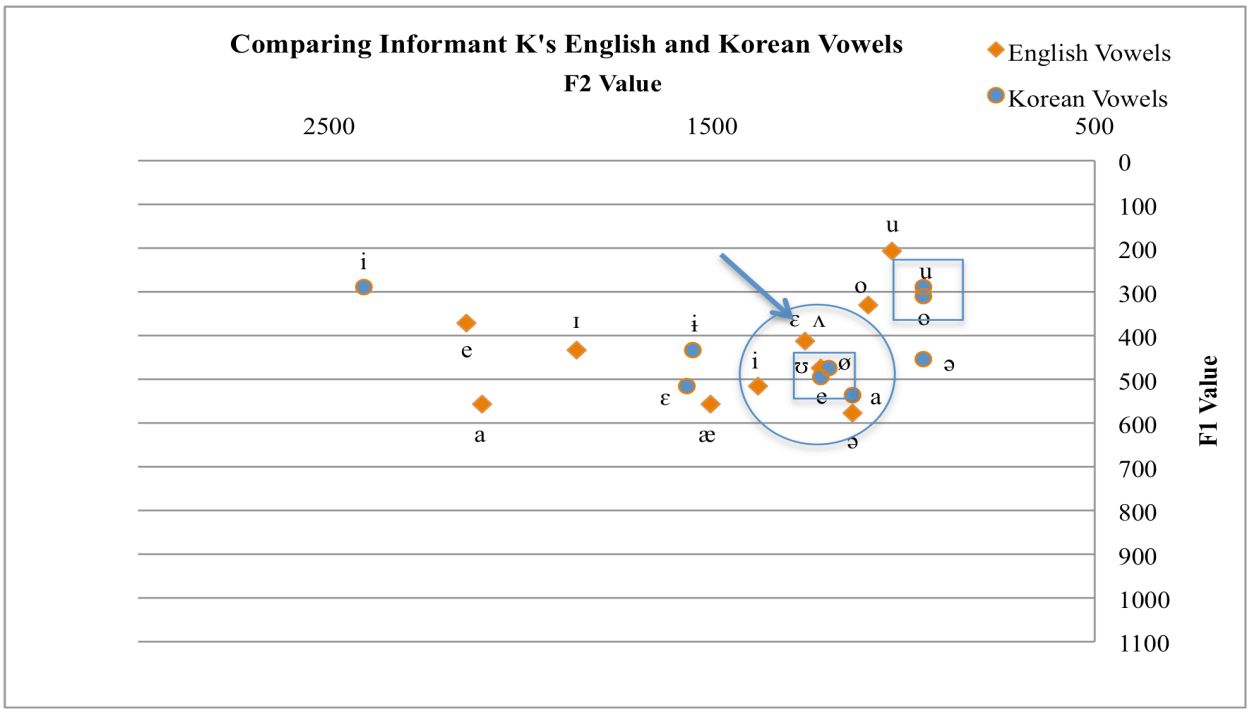

DIAGRAM 1. Examples of vowel clustering and collapsing.

That said, this terminology will be used for the remainder of the chapter when trends in vowels are discussed. These terms cannot be used interchangeably and refer to different phenomena in vowel movement, though it should be noted that one process can transition into another, such as clustering resulting in collapsing.

Yang (1996) measured the F1-F3 and F0 values of 10 Korean vowels and 13 American English vowels produced by 10 male and 10 female speakers of each language group. Throughout the study, he standardized dialectal factors to eliminate as much inconsistency amongst speakers in each language group as possible. To increase precision in his comparisons, Yang applied uniform scaling[17] within and across Korean and English to further reduce variation. As there is noticeable variation in vocal tract length between male and female speakers and

[17] Uniform scaling is a linear transformation that enlarges or diminishes data by a scale factor that is the same in all directions. Yang applied uniform scaling to his formant data within and across English and Korean so as to produce a more precise comparison.

between Korean and American English speakers, I will only use the measurements Yang gathered from female speakers.[18] Finally, to determine any possible statistical significance in the data, Yang's statistical tests showed a significant difference between Korean and English vowels. Table 27 provides the average values of the first three formants (F1, F2, F3) and their standard deviations (in parentheses) for the American female speakers' vowels, and Table 28 presents the average values of the first three formants and their standard deviations (in parentheses) for Korean female speakers' vowels.

TABLE 27.[19] Yang's average values of F1, F2, F3 and their standard deviations for the **American English** female speakers' vowels.

Vowel	F1		F2		F3	
ɪ	466	(51)	2373	(164)	3014	(94)
u	417	(29)	1511	(326)	2796	(169)
i	390	(32)	2826	(140)	3416	(162)
ʊ	491	(56)	1486	(172)	2836	(154)
a	782	(106)	1287	(97)	2563	(173)
ɛ	631	(57)	2244	(190)	2968	(84)
ʌ	701	(75)	1641	(89)	2901	(108)
æ	825	(81)	2059	(208)	2928	(95)
ə	523	(69)	1550	(110)	1927	(254)
e	521	(70)	2536	(138)	2991	(77)
o	528	(73)	1206	(183)	2824	(143)

[18] Though this particular research endeavor only studies the effects on females, the possible disparity in effects on males has not been neglected. In fact, this potential venture of studying the effects of L2 on L1 across gender and exploring whether gender has any effect on these findings would be interesting. Future research is encouraged to take route in this direction.

[19] Though Yang measured for vowel formants at F0, for the purposes of this particular research we did not measure for F0 and thus his values for F0 are excluded from this report of his findings. They can, however, be found in his research cited in the References.

TABLE 28. Average values of F1, F2, F3 and their standard deviations for the **Korean** female speakers' vowels.

Vowel	F1		F2		F3	
e	650	(113)	2377	(77)	3068	(117)
ɛ	677	(108)	2285	(169)	3063	(141)
a	986	(107)	1794	(108)	2957	(227)
o	499	(60)	1029	(143)	3068	(159)
u	422	(83)	1021	(139)	3024	(138)
ø	602	(109)	2195	(152)	3013	(132)
i	344	(48)	2814	(168)	3471	(177)
y	373	(62)	2704	(95)	3222	(108)
ɨ	447	(68)	1703	(106)	2997	(173)

Figure 3 presents Yang's formant measurements given in Table 27 mapped onto a formant chart, and Figure 4 depicts Yang's formant measurements given in Table 28 are mapped onto a formant chart. As discussed in Chapter 2, both formant charts exemplify the method of plotting the F1 values against the F2; thus, the horizontal axis represents the F2 values and the vertical axis represents the F1 values. Essentially, this intersection of the F1 and F2 best captures the acoustic qualities of the vowel (Hayward, 2000).[20] Both Figure 1 and 2 depict graphically the proximity of one vowel to another, which helps illustrate the general shape and distance between cardinal vowels.[21]

[20] More reference on vowel qualities and formant measurements can be read in Chapter 2.

[21] Cardinal vowels are a set of reference vowels used by phoneticians to describe the sounds of languages. Specifically, a cardinal vowel sound is produced when the tongue is in an extreme position, either front or back, high or low. The [i], [ɑ] and [u] are the main cardinal vowels considered to be the three 'corner vowels,' relative to which all other vowels are generally auditorily equidistant at four degrees of aperture: close (high tongue position), close-mid, open-mid, and open (low tongue position).

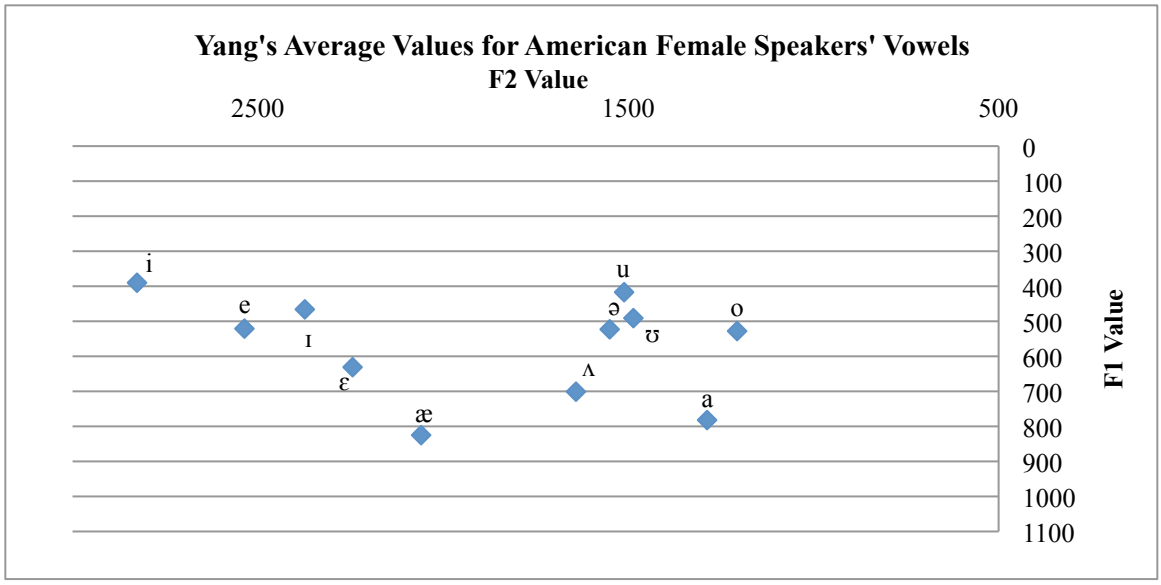

FIGURE 3. Yang's average values for American female speakers' vowels.

Generally, we see in Figure 1 that the American English vowels hold to their shape, with front vowels in the front and back vowels in the back, as expected. Likewise, we see this same trend in Figure 2 with our Korean vowels.

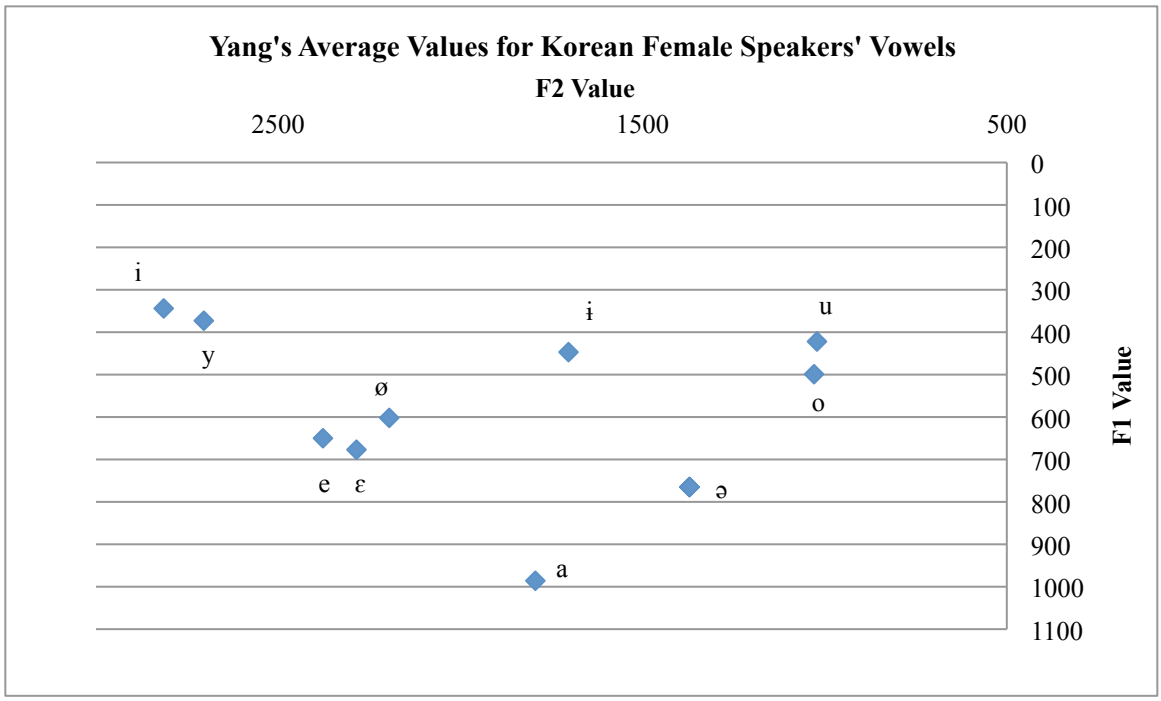

FIGURE 4. Yang's average values for Korean female speakers' vowels.

For comparison, I also mapped both sets of Yang's average vowel measurements for each language onto one formant map, as shown in Figure 4. Importantly, when combined, there is no considerable disparity between the shapes of vowels in each language. Despite a few differences in the sounds available in the language, due to the general close proximity of English and Korean vowels, it appears that even for the sounds that are directly unavailable, there is a reasonably close enough vowel to serve as a comparable alternative (Best, 1995). Hence, when both sets of vowels are mapped onto a chart together as we see in Figure 3, there are no extreme outliers, which would prove difficult to pronounce should that sound be absent in the other language. Hence, discounting any articulatory difficulties one may face in acquiring sounds in the other language, in terms of general proximity of English and Korean vowels, it appears that clusters of vowels that share the same place of articulation reside within the same neighborhood of sounds.

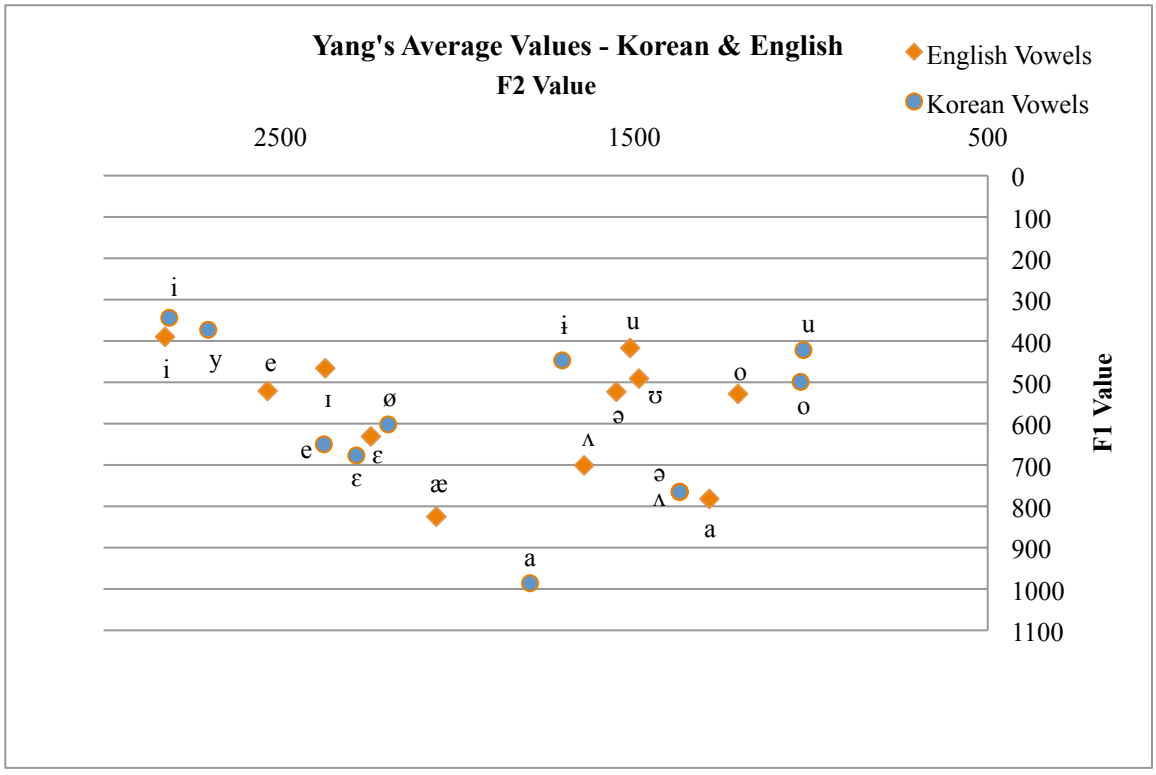

FIGURE 4. Yang's average values for Korean and English vowels depicted on one formant chart.

Vowel formant frequencies represent the main acoustic correlates for vowel quality. Frequencies are also important as they represent the acoustic characteristics of speech. Fant (1970) argued that a speech wave is a response of the vocal tract filter systems to one or more sources of sounds, introducing the source-filter model of speech production. This model proposes that speech should be understood as a combination of a source sound, vocal cords in this case, and a linear acoustic filter, or the vocal tract. Essentially, this model explains that different phonemes can be distinguished by the properties of their sources, hence the importance of formant frequencies because without them it would be difficult to set each one apart from the others. Peterson and Barney (1952) also look into the relationships between listeners' recognition of a spoken vowel and the vowel's properties in terms of acoustic measurement of sound waves. They argue that both the utterance and accurate identification of the vowel depend upon the individual's language and dialectal backgrounds as well as their vocal and auditory characteristics, which also corroborates the importance of looking at formant frequencies. Studying individuals' vowels is an integral part of my particular study as well. Formant frequencies help to capture a holistic story behind vowel production, especially those accented by developing L2 sounds. Since each informant is distinct, there is variation in formant values depending on the speaker, yet variation is especially interesting to this study as it relates to different foreign accents affecting vowel production.

4.2 Revisiting Informants by Groups

All of our informants have been categorized into a specific sociolinguistic group that best represents their upbringing, language identity and social and family dynamics. The following sections will enumerate the findings by group. A brief description of the composition of the group under study will be provided as a preface to each subsection.

4.3 Introduction to Informants' Vowel Maps

The following section will show the formant measurements for each informant's Korean and English vowels. As described earlier in Chapter 2, the same set of measurements will be given in the following ways: first, each set of vowels in English and Korean will be given individually and then together onto one map. The collective mapping will help to highlight extremities in their vowel inventories and noticeable outliers amongst vowels in both languages. Second, for purposes of comparison, informant's English vowels will be mapped with Yang's measurements together to underscore any disparity from average measurements, and likewise for Korean as well. This will help show differences between our informants' vowels and those found by Yang's measurements, and will help to determine how much of these differences can be attributed to social factors, such as differences in upbringing and language identity. The section ends with a discussion on noticeable trends and patterns in our findings. There will be discussion based upon collective features observed by groups followed by a holistic discussion on our findings in an attempt to draw final conclusions regarding our results. The sections to follow will only show exemplar vowel maps; however, all maps for every informant can be found in the Appendix. While the analysis will only describe features of the most pertinent findings, reference to the Appendix to specific Informants (A-K) is encouraged.

4.4 Analysis

The following discussion will show that all informants demonstrate a general quality of backness in both their English and Korean vowels. This is particularly interesting given that certain informants were given high ratings for level of fluency in either language, and thus noticeable patterns in vowels, especially that of backness, are inconsistent with expectations of

fluency. This is very profound as it shows that my informants are not different because of happenstance and because I selected informants who were different from those used by Yang – this general trend of backness strongly suggests that certain features are simply inherent to Korean-English bilinguals. In other words, these vowels are affected because of the very fact that two languages have come into contact, a notion I call the bilingual effect on vowels. This is also corroborated because Yang specifically used monolingual speakers for each language, which when compared to the bilinguals who were used in my research, only further emphasizes that these affected vowels are a result of bilingualism. Like Yang, I, too, calculated the average formant values for my informants' English and Korean vowel, which can be seen in Tables 29 and 30 (below).

English	AVG F2	AVG F1
/ɪ/	1554	459
/u/	1075	300
/i/	2180	358
/ʊ/	1049	430
/a/	1508	534
/ɛ/	1459	433
/ʌ/	1363	379
/æ/	1508	566
/ə/	1342	452
/e/	1921	360
/o/	967	433

TABLE 29. Kim's Average Values for Korean Female Korean-English Bilinguals' English Vowels.

Korean	AVG F2	AVG F1
/e/	1659	473
/ɛ/	1622	489
/a/	1386	690
/o/	1202	345
/u/	1040	368
/ə/ (/ʌ/)	961	435
/i/	2450	375
/y/	1658	382
/ɨ/	1477	411
/ø/	1511	404

TABLE 30. Kim's Average Values for Korean Female Korean-English Bilinguals' English Vowels.

Figure 5 presents these calculated average values for Korean vowels, and Figure 6 presents the calculated average values for my informants' English vowels.

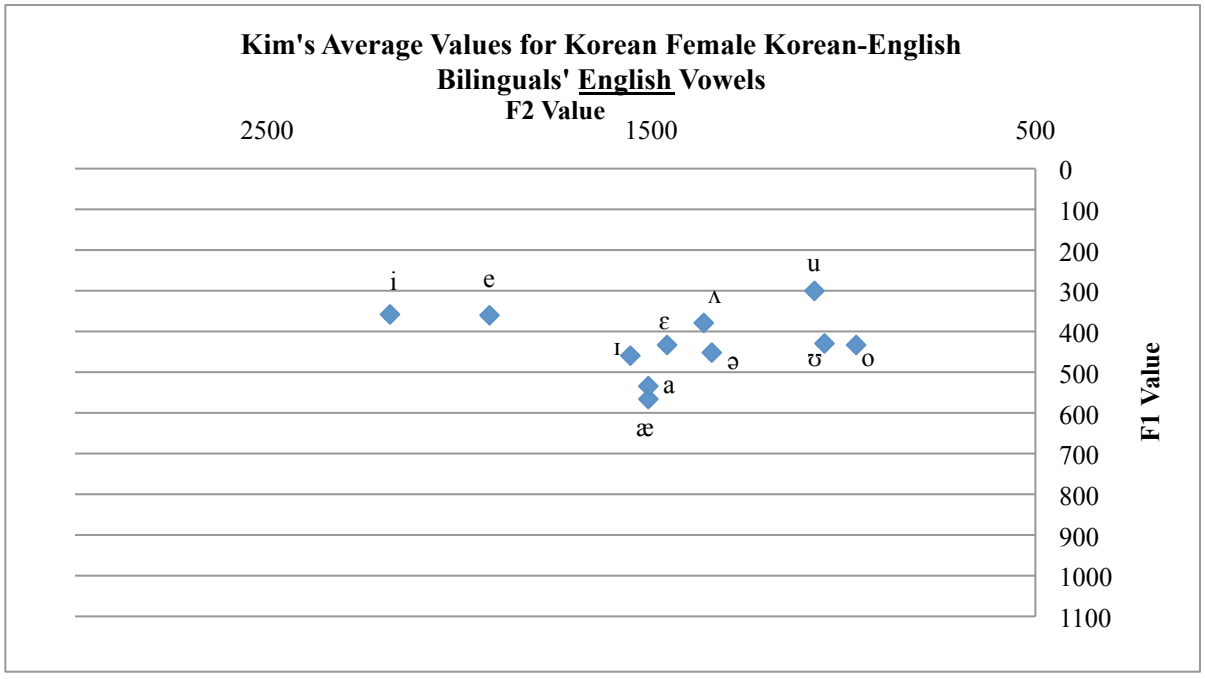

FIGURE 5. Kim's average values for Korean female Korean-English bilinguals' English vowels mapped onto a formant chart.

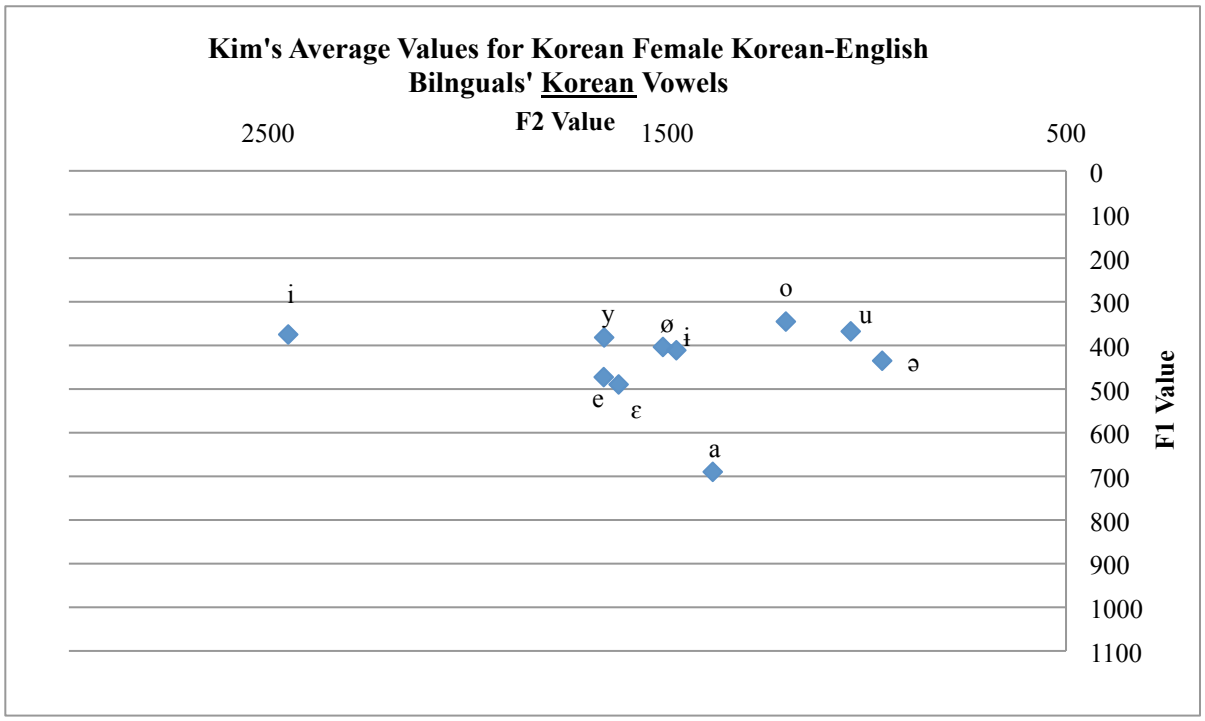

FIGURE 6. Kim's average values for Korean female Korean-English bilinguals' Korean vowels mapped onto a formant chart.

Even holistically, as evidence in Figures 5 and 6 (above), the notion of backness in vowels in both languages is supported at large. This trend is visible even after all the formant measurements are averaged, which is important because it demonstrates that this is a pattern observed in all informants, rather than any one particular outlier.

Also important to note is that both Yang and I used comparable numbers of informants; while he used groups of 10 monolinguals for each language, I used 11 bilingual informants; thus further emphasizes that it is, in fact, the bilingualism that is causing these noticeable trends in vowels. This bilingual effect will be elaborated on further in the discussion of the control in the following section.

4.4.1 GROUP 1 – Characteristics

As described in Chapter 2, Group 1, the control, is proficient in both English and Korean. The control was born and raised in Korea for most of early childhood, moved to the United States and resided in the US for the remainder of late childhood into adulthood. The Korean language is typically used in the home with family, while English is used more often in academic settings though with friends and social groups (which tends to be predominantly Korean in composition), Korean is preferred. In sum, this informant, my control, demonstrates a strong command of both English and Korean and can transition between languages when need be with ease and great fluidity. Additionally, the control has been formally educated in Korea, and thus studied the Korean language formally. As presented in Chapter 3, independent evaluations by native speakers of Korean and English confirmed that the control was fluent in both English and Korean by assigning the control a score of 5 in both languages, the highest mark corresponding the highest level of proficiency.

Given this background, we expect her to have fully developed phonemes in both English and Korean. To account for her mastery of sounds in both languages, we expect the control to have acquired vowels sounds in Korean and English, given her high proficiency in both. More importantly, we expect that when her vowels are mapped onto a chart, that the general proximity and shape of vowels closely resembles those found in Figure 1 and Figure 2. Our expectation is that since all sounds are acquired and that representations in both languages have been fully formed, vowels in Korean and English will be properly spaced with no evidence of collapsing vowels.

4.4.2 Discussion of Informant E – The Control

Informant E was born in Seoul, South Korea. Intermittently, however, she spent about 3 years in Singapore, and 2-3 years in Virginia. She has spent most of her childhood and early adolescence in Korea, a total of 12 years of her life. While she attends Wellesley College, her family still resides in Seoul. Korean is the native language of both her mother and father. Informant E also recalls Korean as the first language used in the home, thus becoming her L1. She also reports that her father uses mostly Korean with her, while her mother, sibling and grandparents use only Korean with her. She adds that her friends tend to use Korean and English equally when interacting with her. Interestingly, she also reports some disparity in the type of language input she receives from these people. For example, while her father uses mostly Korean to her, she however, tends to use equal amounts of Korean and English in her responses. Her interactions with her mother seem to be fairly reciprocal, as both her and her mother tend to use mostly Korean with one another. The same appears to be true about her interactions with her sibling and with her grandparents, both sides using only Korean in their collective exchanges.

Most notably, however and true to the attributes as an individual demonstrating fluency in both languages, is her acknowledgement of employing equal amounts of English and Korean when with her friends, indicative of her ability to easily access either language.[22] Additionally, while she herself shows a natural tendency to use both Korean and English, her friends in everyday conversation also reciprocate this by their use of mixed input of both Korean and English. This is perhaps also indicative of her ability to perceive subtle differences between

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[22] Though this remains outside the scope of this research, Informant E also demonstrates an ability to code-switch between Korean and English, further evidence of the vowel sounds she has acquired in both languages. Informant E's code-switching in conversation between Korean and English is effortless and seamless. There is an immediate transition from one set of sounds in one language to the next set of sounds in the other language, almost as though she "turns off" the sounds unique to the first language to "turn off" the sounds specific to the second language. Further research in this field may yield interesting results and greater insight into bilingualism in Korean and English.

similar vowels from both languages, most notably the contrastive pairs /i/ - /ɪ/, /eᴵ/ - /ɛ/, /ɛ/ - /æ/ and /ɑ/ - /ʌ/ (Tsukada, Birdsong, Bialystok, Mack, Sung, Flege, 2005). Thus, given this background on our Informant E, her formant measurements for both her Korean and English vowels yield a telling story. Figure 7 presents Informant E's English vowels plotted using F1 and F2 measurements for each vowel.

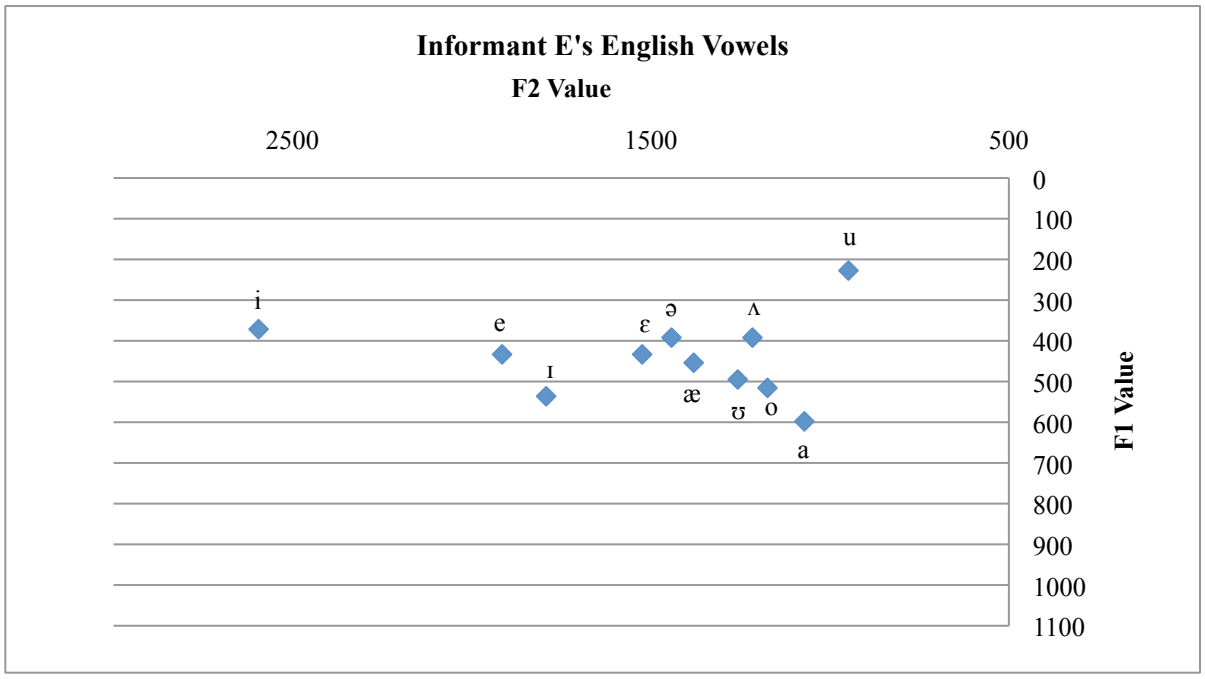

FIGURE 7. Informant E's English vowels.

One of the immediate features to notice is the deviation from our expectations in vowel shape. There is a noticeable shift in the front-central vowels, particularly /e, ɪ, ɛ/. The /e, ɪ/ have shifted back, with /ɛ/ collapsing with the central-back vowels. The most prominent feature to take note of is the general collapsing of central-back vowels. Though the cardinal vowels remain intact, English vowels such as /æ, ʌ, ʊ, o/ are all collapsing into one another, which is curious since these vowels vary in acoustic quality. In general, Informant E's English vowels seem to demonstrate holistic traces of backness, especially noticeable in her /u/ which is further back than is expected, especially when comparing these particular vowel measurements to those of

Yang's normalized values. Similarly, Figure 8 presents Informant E's Korean vowels plotted onto a formant chart, while Figure 9 shows Informant E's English and Korean vowels mapped on top of one another.

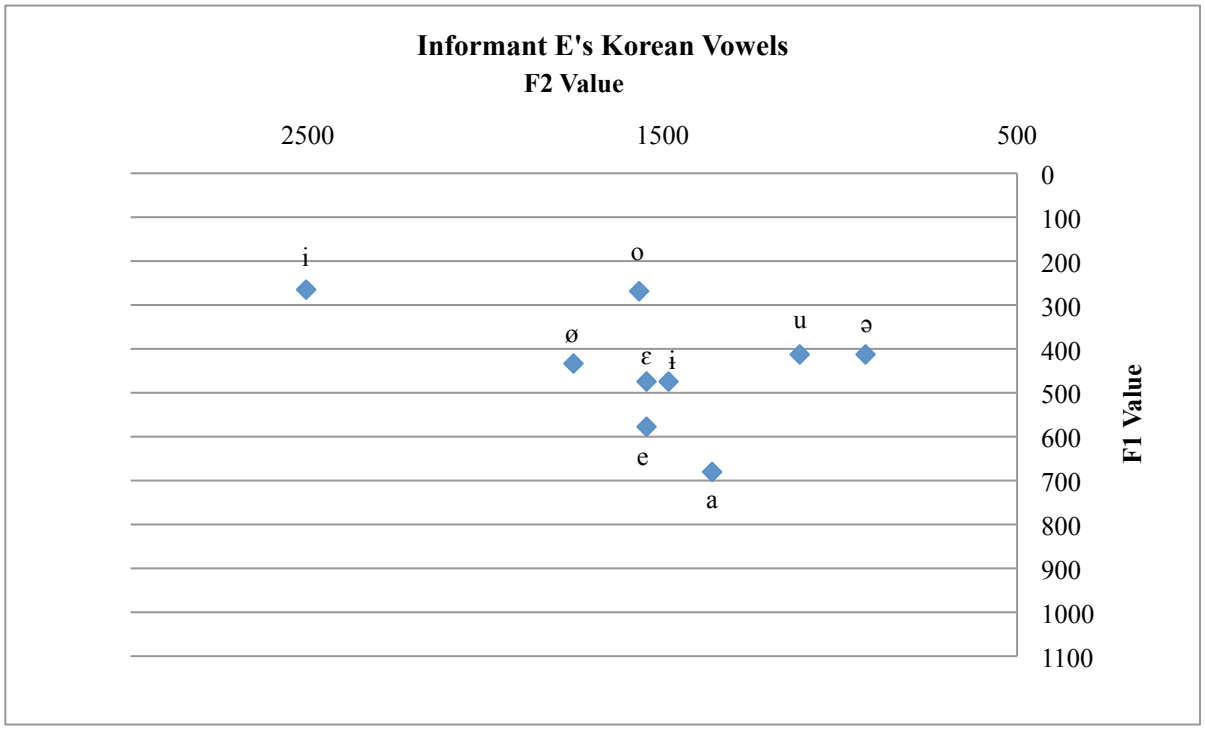

FIGURE 8. Informant E's Korean vowels.

With regard to her Korean vowels, there is even more noticeable shifting towards the back. In fact, even though she is rated highly in her proficiency of English and Korean, Informant E's Korean vowels seem to suggest a slight cluster in her back vowels, having tremendous effect on her /o, ɛ, ø/ vowels. Due to the shift of these particular vowels, which are normally front-central vowels, Informant E's Korean vowels become predominantly central-back vowels, with heavy emphasis on the presence of back vowels.

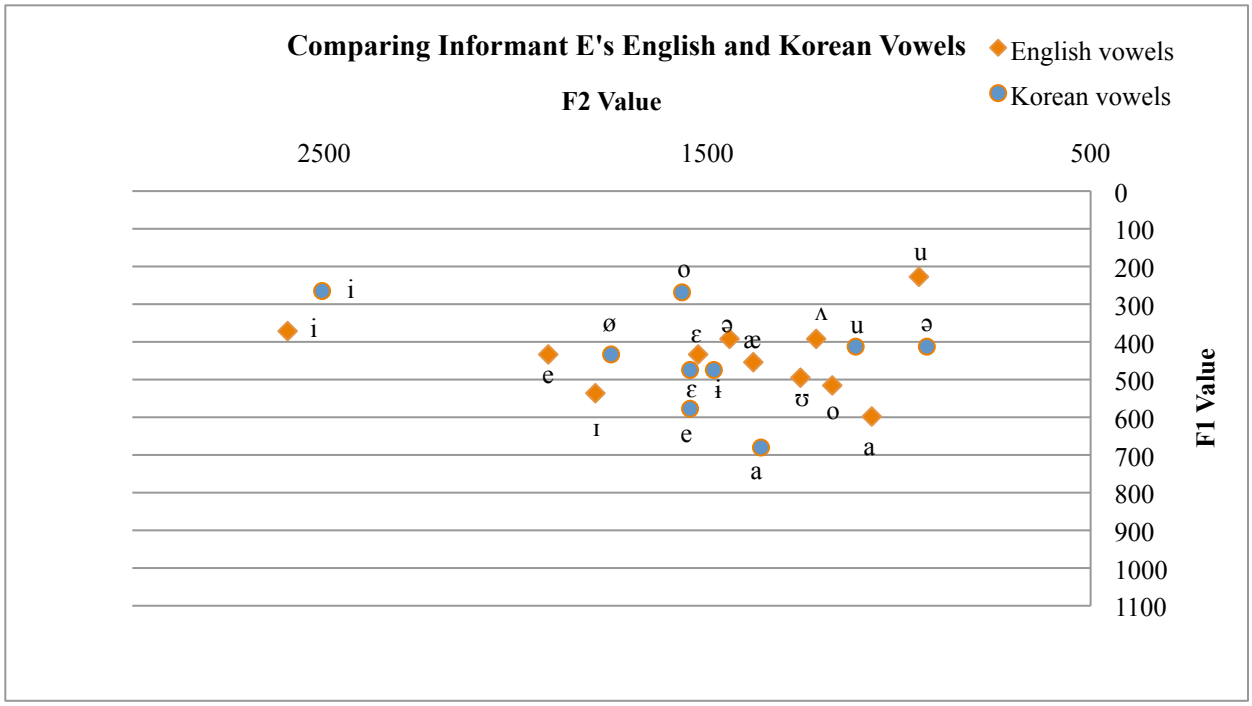

FIGURE 9. Informant E's English and Korean vowels.

Collectively, as seen in Figure 9 (above), however, her cardinal vowels in both English and Korean are plotted according to expectations, which can perhaps be attributed to her proficiency in both Korean and English – despite revealing anomalies in certain vowels, the preservation of her cardinal vowels and most of her other vowels with the exception of a few collapsing instances suggests that her L1 representations were acquired and less prone to influence of developing L2 categories, and that even once her L2 categories took shape, her L1 representations stayed in place.

The shift in her Korean vowels, which she reports Korean to be her L1, could suggest the possibility that a general shift in Korean vowels to resurface as back vowels may be a natural phenomenon that occurs when English and Korean come into contact and create a bilingual interface. This is further corroborated by the fact that Informant E is highly proficient in both English and Korean – that even though she is observably fluent in both languages, the two-directional effect of the L1 on the L2 and the L2 on the L1 is inevitable and beyond one's

control. Thus I suggest a bilingual effect, specifically that certain phenomena occur naturally as a result of bilingualism. To underscore the peculiarities in Informant E's English vowels, Figure 10 (below) re-depicts Figure 7 with features and trends highlighted, and Figure 11 will re-illustrate Figure 8 to help illustrate the anomalies in Informant E's Korean vowels.

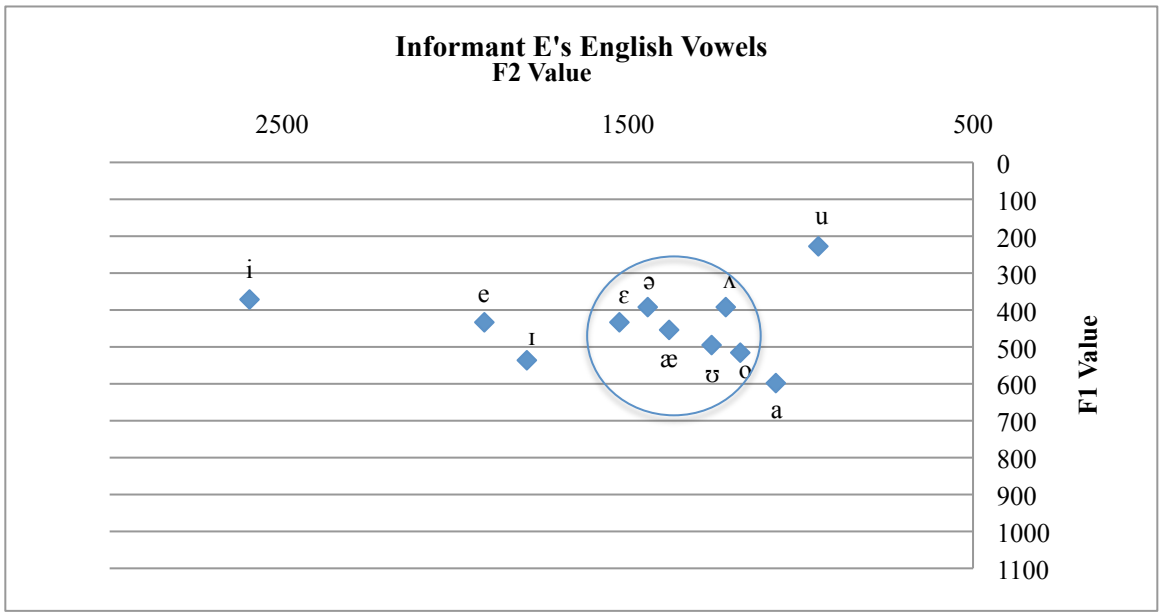

FIGURE 10. Informant E's English vowels.

The circled vowels indicate the vowels that have started to cluster. The vowels outside the collapsed area show the cardinal English vowels that have managed to remain unaffected by the existing L1 categories in Korean.

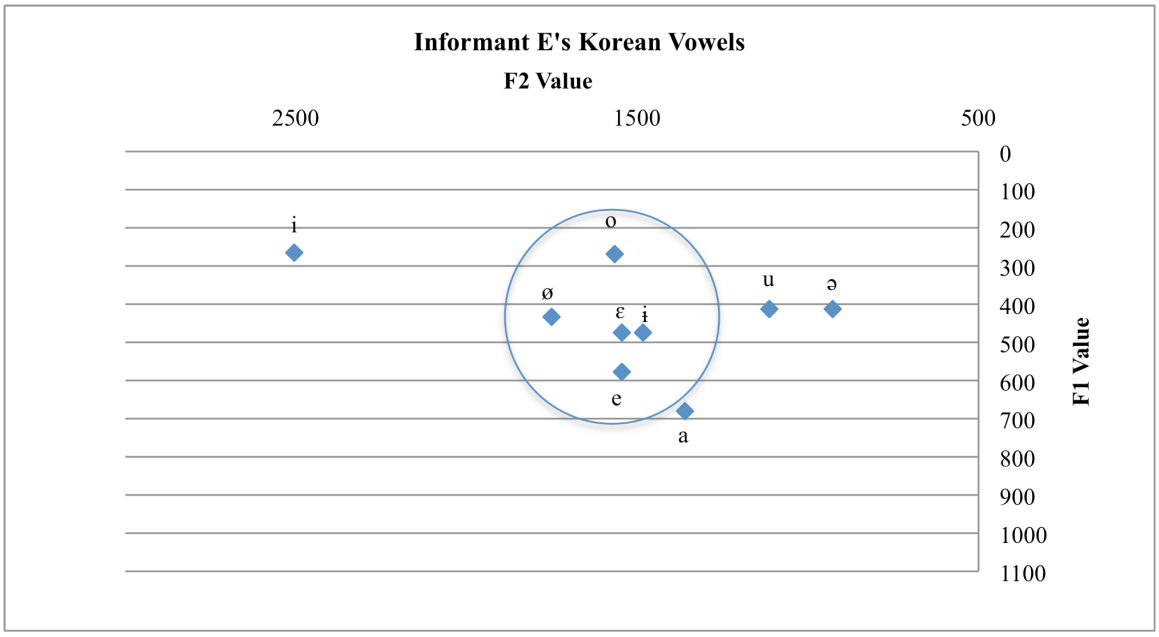

FIGURE 11. Informant E's Korean vowels.

Likewise, the circled vowels indicate the Korean vowels that have started to cluster. The vowels outside the collapsed area show the cardinal Korean vowels that have managed to remain unaffected despite the presence of developing L1 categories in English. Both Figures 7 and 8 seem to suggest that viability of interacting vowels in both English and Korean cause both sets of vowels to be ultimately affected, which is manifest in their shifting locations to form clustered concentrations of vowels. Furthermore, as a comparison, Figure 12 (below) presents Informant E's English vowels overlaid on top of the English vowel measurements given by Yang. The shifting movement is particularly noticeable as front vowels shift back, clustering with other central-back vowels.

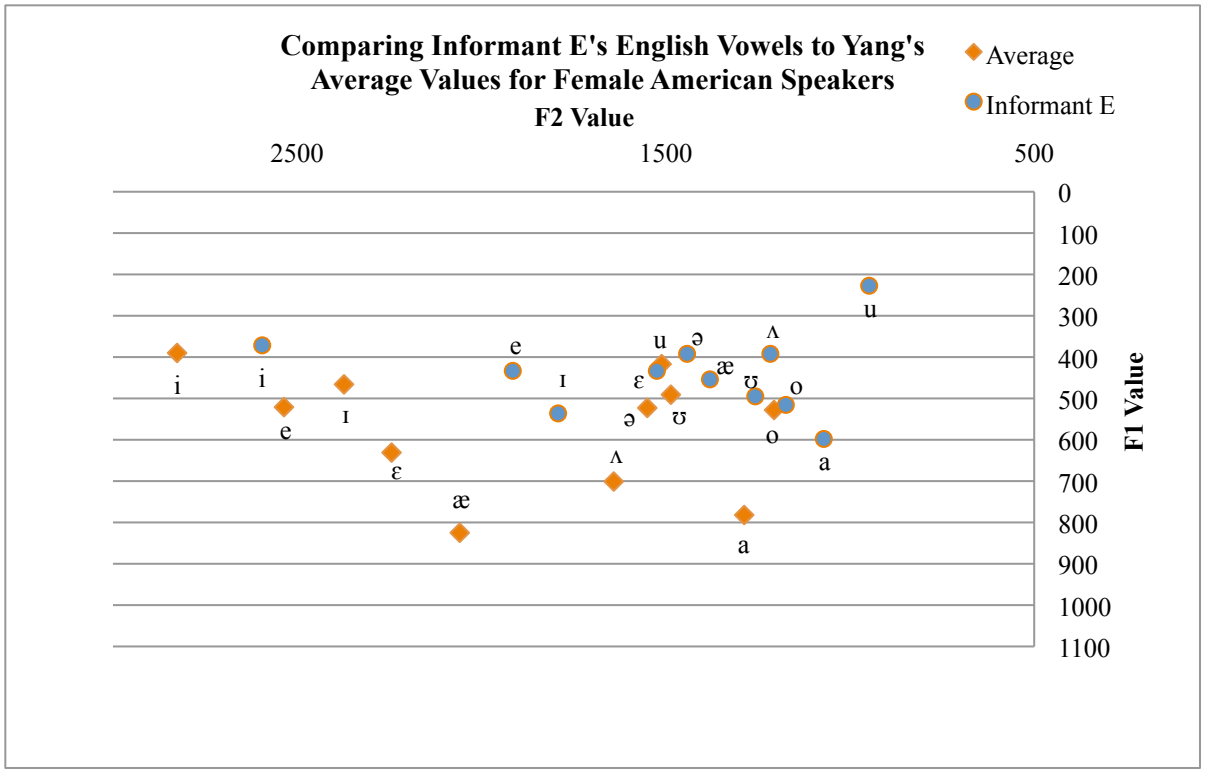

FIGURE 12. Comparing Informant E's English vowels to Yang's average values for female American speakers.

Similarly, Figure 13 (below) shows Informant E's Korean vowels plotted on top of the vowel measurements given by Yang's average values for female Korean speakers. The arrow indicates the direction in which the shift is occurring, predominantly towards the back.

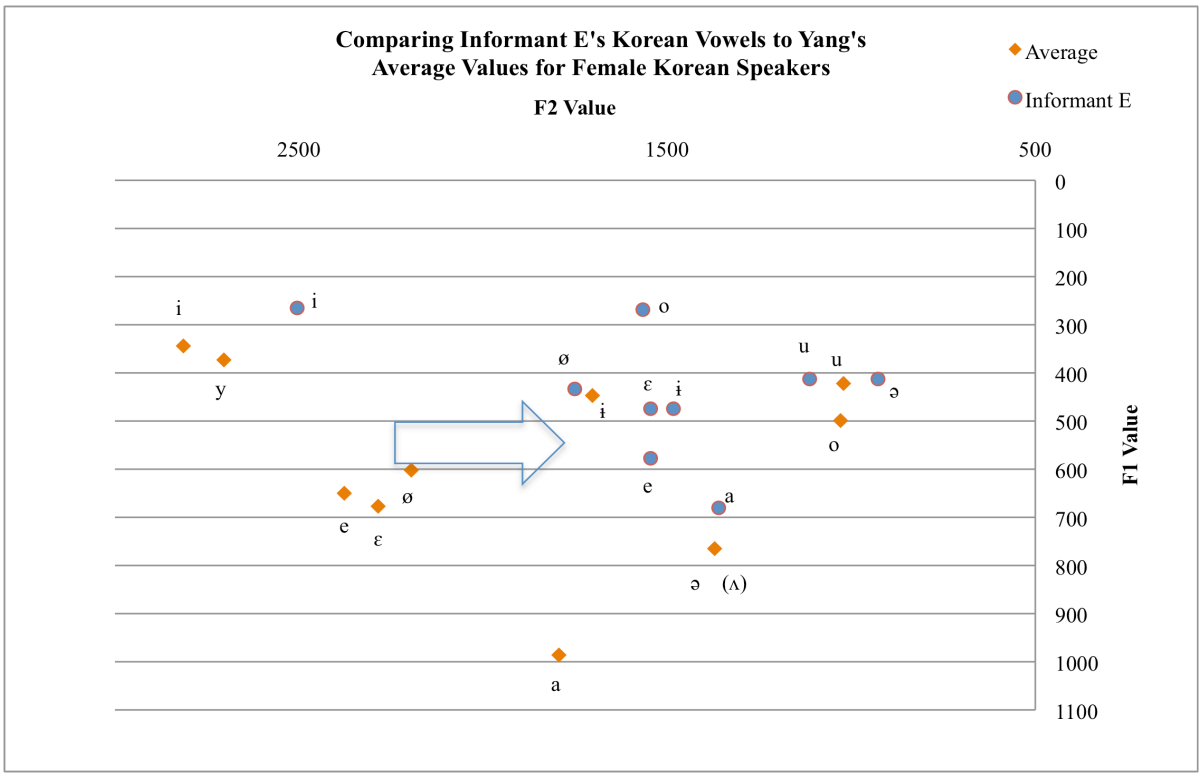

FIGURE 13. Comparing Informant E's Korean vowels to Yang's average values for female Korean speakers.

In sum, there is noticeable shifting of vowels in both the L1 and L2 even with my control, which suggests that there is perhaps a phenomenon occurring that is naturally inherent to bilingual speakers of Korean and English. It seems likely that the interface between the English and the Korean triggers this onset of vowel movement. Now, we will look at Group 2 for further comparison and discussion.

4.4.3 GROUP 2 – Characteristics

As described earlier, Group 2 consists predominantly of informants who demonstrate fluency in English while showing a working understanding of Korean, which they consider to be their L2. This working understanding of Korean is typically characterized by frequent difficulty with pronouncing certain sounds in the language. General L2 production tends to be hindered by heavy traces of a foreign accent in their Korean, thus indicating that these sounds have only been

partially acquired. These informants were born and raised in the US, and have rarely visited Korea. Members of Group 2 use mainly English in the home as well as in social settings. While the mother and father of these informants may consider Korean their L1, they still choose to communicate with their daughters in English. Or, as is frequently done, the informant will still respond in English even if addressed by her family in Korean.

Members of Group 2 may have been exposed to Korean at an early age and for a few years during early childhood, but quickly transitioned to English thereafter, which eventually became the L1. The point of transition from Korean and English usually occurs between 2-4 years of age for all informants in this category. At this point, it is most often the case that Korean is used with significantly reduced frequency as it is replaced by English in the L1 role, hence many of the sounds in the Korean language that were once native become foreign, and are lost and almost forgotten. Now as young adults, they are undergoing a resurgence of Korean as they hear it more often amongst friends who identify with the Korean and Korean-American communities and informants become more accustomed to sounds as they hear it through pop culture and various social outlets and mediums. These informants have also only attended school in the US and thus, have only been taught in English. They may have taken a class in elementary Korean, but never have they been educated in the language directly.

It is expected that these informants will demonstrate fully acquired English vowel phonemes, but partially developed vowel phonemes in Korean. We may expect certain cardinal vowels in Korean to be intact, but holistically, we expect many of the Korean vowels to have shifted to some degree, hence the noticeable foreign accent in their production of Korean. When looking at their vowel maps, we expect the shape of their vowels and relative proximity to one

another to resemble the vowels depicted in Figure 1, which shows the measurements found by Yang for female American speakers. As an exemplar of this group, I will use Informant J.

4.4.4 Discussion of Informant J and Revisiting L2 Acquisition Models

Informant J was born in Redmond, Washington and was raised in the US. She has spent all of her childhood, adolescence as well as young adulthood in the States and has never visited Korea. English was the first language used in the home, and thus became her L1, though some Korean was heard throughout early childhood and even into young adulthood. Though Korean is the L1 for both her mother and father, she uses only English with them when communicating. In fact, English is her main mode of communication when interacting with anyone, whether it is with her family such as her siblings or grandparents or simply her friends. Interestingly, Informant J has many friends who are of Korean descent and reports having been a part of Korean speaking communities for at least 5 years, which suggests that she has received, to some degree, continued exposure to the Korean language. Though she may not produce Korean regularly, she is constantly exposed to the language and hears it quite often at Wellesley. In fact, because Informant J was exposed to Korean to some degree, however limited, in the home, it may be easier for her to perceive Korean sounds now as a young adult due to earlier experience (Knightly, Jun, Oh, Au, 2003). Though L2 production may remain challenging, hearing and perception may be easier, especially compared to the level of difficulty a new L2 learner may encounter. As a heritage learner,[23] Informant J has some acquisition of L2 representations,

[23] As discussed earlier in **1.4.4 Integrating Heritage Learners**, a heritage language is a language that is acquired by individuals who are raised in homes in which the dominant language of the region, such as English in the United States, is not used or not used exclusively. Furthermore, a heritage language is typically acquired before the dominant language, or L1, but is not completely acquired because the individual changes to the dominant language, which becomes the L1, before complete acquisition of the heritage language.

though very limited. As Chang (2010) expressed in his research, heritage learners often have an advantage when re-learning a language from early childhood.

The expectation is that Informant J's English vowels have remained uninfluenced by any developing L2 categories, since English is her L1 and Korean a distant L2. In fact, the independent ratings gave Informant J a 5 for her level of fluency in English, the highest possible mark, and a 1 for her level of fluency in Korean, the lowest possible mark on the scale.

Interestingly and unexpectedly, I observed that many of Informant J's English vowels have shifted and demonstrate noticeable levels of backness. This also proves consistent with Informant E, the control, who despite expectations to have un-shifted English vowels, also seemed to have underwent some kind of drift in vowels, both Korean and English. Even more so, one particularly telling feature in Informant J's English vowels is the clustering that is seen in her vowels, predominantly those in the central-back region. Her /u, a, ɪ, ə, ʌ, ɛ/ have all been collapsed into one amalgation of a vowel sound. This is particulary noteworthy becuase all of the aforementioned vowels differ in quality and thus require varying articulatory gestures. It is as though non-collapsible vowels have managed to collapse into one melded vowel phoneme. Again, while her cardinal vowels are comparable to those found by Yang's informants, the cluster of vowels seems to suggest otherwise with the /o/ and the /ʊ/ collapsing as well. Likewise, her /i/ and /e/ are also collapsing into seemingly one vowel sound. Informant J, in fact, demonstrates clustering in very defined groups, with three noticeable clusters on her maps. Below, Figure 14 presents Informant J's English vowels. The vowels circled reveal three clusters of phonemes, with even many of her cardinal vowels clustering with nearby vowels to form possibly one melded phoneme. Most intriguing is the larger cluster of vowels in the mid-back region.

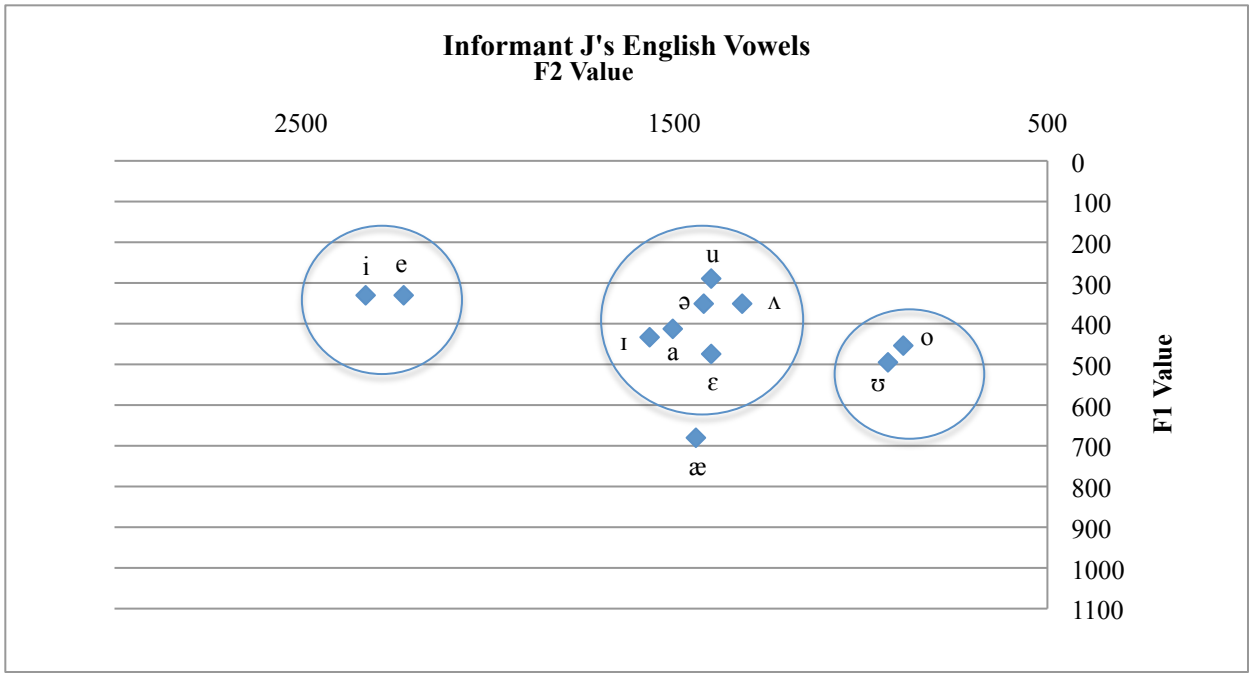

FIGURE 14. Informant J's English vowels.

These features are even more noticeable when directly compared to Yang's measurements, as illustrated in Figure 15, which shows Informant J's English vowels as well as Yang's values.

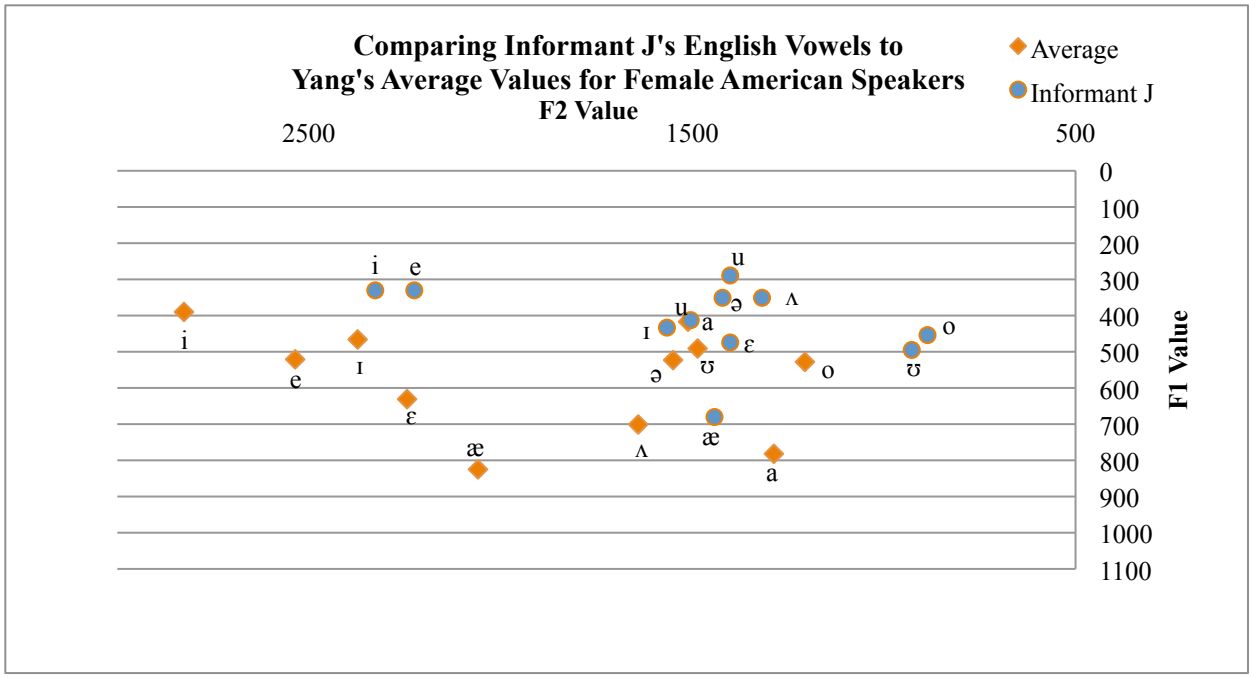

FIGURE 15. Comparing Informant J's English vowels to Yang's average values for female American speakers

Interestingly, significant clustering can be observed again in Figure 15, most notably in her front vowels – many of them have shifted in location, and subsequently, clustering with her back vowels

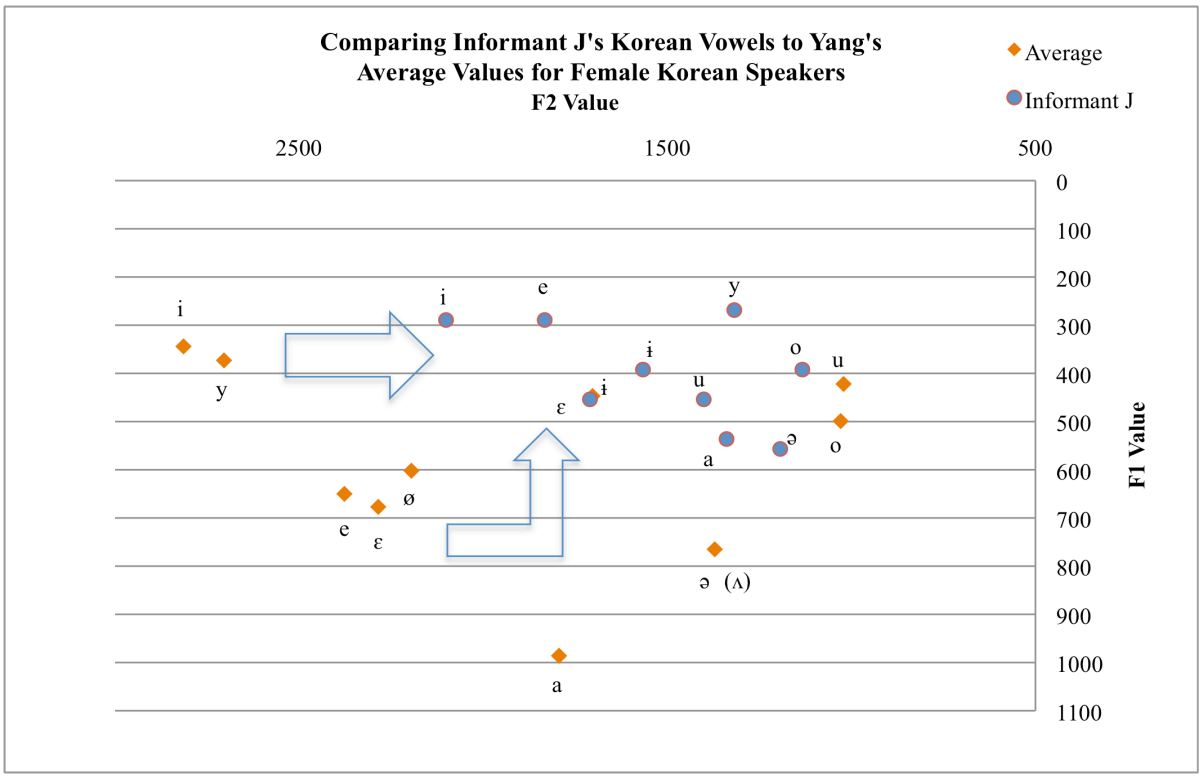

FIGURE 16. Comparing Informant J's Korean vowels to Yang's average values for female Korean speakers.

Informant J's Korean vowels also provide a telling story. The arrows seen above in Figure 16 highlight the direction of shifting Korean vowels, which happen to parallel the exact direction of shifting evidenced Informant E's Korean vowels. As expected, her Korean vowels deviate quite significantly from the expected vowel shape, with many of her vowels noticeably shifted in placement, most likely due to the fact that Korean is her L2 and many of her representations have yet to be fully acquired. Interestingly, however is the precise direction in which her vowels have shifted, and the strong resemblance to the shift observed in our findings from Informant E. This may help to corroborate our theory regarding the nature of these vowel

shifts – perhaps they occur naturally when a close interface develops between English and Korean.

Discussion of Informant J also supports the need for a more comprehensive model that proposes two-directional influence. The findings on Informant J challenges whether the effects of one language can only occur in one particular direction. I would like to propose that influence might be working in both directions. Considering this option would also allow us to account for more of our findings. Earlier, I introduced several models intended to enhance our understanding of L2 acquisition and engage in the possibility of reverse effects – L2 affecting the L1. It is important to consider the ways in which each model may apply to our specific research and if perhaps we can attempt to devise a more comprehensive model that can account for existing shortcomings and incite greater insight into this research subfield. Before we proceed, it would helpful to revisit some of those models

The discussion on the Perceptual Assimilation Model (PAM) (Best, 1993, 1994, 1995) which helped to explain L2 phonological acquisition in the early stages. PAM is essentially designed to set forth various typologies to account for ways in which non-native speech contrasts may be interpreted by native listeners relative to L1 phonological categories, or as the model describes, "perceptual assimilations." The outcome of this model is that the type of perceptual assimilation that takes place with members of a non-native contrast helps to determine the level of difficulty a learner will have with discerning that particular contrast. For instance, if the contrasts are assimilated according to different L1 categories, then the contrast will be discriminated accurately. However, if the contrast is assimilated to the same L1 category, the contrast will then be discriminated less accurately.

The Speech Learning Model (SLM) (Flege, 1988, 1992, 1995), on the other hand, proposes that L2 speech learning was based upon the foundation that phonetic systems undergo reorganization in response to sounds encountered in an L2 through developing phonetic categories or through the modification of existing ones. Essentially, in this particular model, by suggesting that existing representations are in flux and could thus be experiencing phonetic change, Flege introduces the possibility that L1 categories are also prone to shift as developing L2 sounds start to fossilize. This idea of shifting vowels is integral to the development of a new model that presents interactions between the L1 and L2 in both directions. This notion of shift corroborates the idea that vowels, regardless of the state of bilingualism, are changing under the effect of emerging sounds or modifications of existing ones.

If L1 is capable of movement, then one can argue that the emerging L2 is partly responsible. This also supports the potential for the bilingual effect, which would mean that even if L2 sounds were not responsible for L1 movement, if drift in the L1 is still occurring, then this could be, in part, attributed to the process of bilingualism itself. Flege underscores the belief that phonetic categories of L1 and L2 are in co-existence in a shared system with the added pressure to preserve each as separate subsystems. This nuanced understanding of sharing sounds in a coalesced system while attempting to uphold a distinction will be critical in my later analysis.

Finally, as discussed earlier, the Perceptual Assimilation Model-L2 was a revised version of PAM. In this version, the principles originally set forth in PAM for non-native speech perception are extended to apply to L2 speech production as well. PAM-L2 goes further to include the effects of an L2 learner's developing phonetic and phonological understanding of L2 on learning the language. This implies that there is perceptual assimilation at the gestural, phonetic and phonological levels. One of the most profound distinctions that the PAM-L2 draws

from the other models, especially PAM, is its emphasis on perceptual assimilation at the phonological level. Best and Tyler say "contrasts at the functional linguistic level of the L1 phonology and their relationship to phonological contrasts of the L2 are as important to perceptual learning as phonetic categories in the two languages" (2007: 26). Additionally PAM-L2 argues that "the phonological level is central to the perception of L2 speech by L2 learners," which draws a special distinction from PAM. This is important because it brings to light the possible significance of phonological systems in language acquisition, rather than focusing solely on phonetic representations, which could mean that emerging phonological processes in the L2 could have effect on existing processes in the L1.

4.4.5 Proposing an Intersection of Models

With all these models under consideration, I believe that my research contributes a piece to this interconnected endeavor to determine the influence of one language on another during L2 acquisition. As mentioned earlier, Informant J poses an interesting case study with which we can try to understand directionality of influence. Though it was difficult to determine accurately whether for Informant E, the collapsing vowels in English were causing the vowel shifts in Korean or whether the shifting Korean vowels were causing the vowel clusters since she demonstrated native-like fluency in her pronunciation of both languages, it is easier to make a claim for Informant J. For Informant J, while we expect her Korean vowels to be partially developed, we expect her English vowels to be fully acquired and have a closer fit to that of English monolinguals, as measure by Yang's standards. On the contrary, many of her vowels have undergone some kind of shift. This mysterious shift is difficult to explain unless it is the case that these changes result from the resurgence of Korean vowels in young adulthood, which

have begun to influence her L1 categories, producing the backness that now characterizes many of her normally front and front-central vowels.

If the emerging L2 can influence the long-standing L1, then it would seem that L1 categories are in flux, which resonates closely with the principles Flege founded his Speech Learning Model. However, Informant J is interesting because rather than suggesting that contrasting sounds in the L2 are assimilated to different L1 categories, which will then determine whether the contrasts will be discriminated (as predicted by PAM), perhaps the case is that contrasting sounds in the L1 try to assimilate with emerging L2 sounds, hence the shifting vowels in L1. Therefore, L1 representations seems to react to emerging L2 sounds, a different perspective to consider when we are looking at the Perceptual Assimilation Model. This motivates the study of the intersection of Flege's Speech Learning Model and the Perceptual Assimilation Model, which allows for influence in both directions.[24]

4.4.6 GROUP 3 – Characteristics

Group 3 consists of bilinguals who demonstrate fluency in Korean and a working proficiency in English. Relative to their Korean, English is considered their L2. Therefore, given

[24] Best and Tyler (2007) also focused on the commonalities between the findings of the Perceptual Assimilation Model (PAM) on non-native perception by native listeners and the findings of the Speech Learning Model (SLM) on L2 perception and production by L2 learners with relatively high levels of proficiency. Despite their findings revealing a convergence in models, Chang (2010) emphasizes that the models describe different populations. Chang strongly emphasizes that because the models are designed to study different populations, they cannot be used interchangeably in discussion. While the PAM focuses on naïve perceivers of non-native speech and generally monolinguals who demonstrate no active participation to learn or use an L2, and are essentially foreign linguistically to the target language. Best and Tyler define these individuals as those who have had "relatively passive exposure to a language other than the L1, that is, for which the listener has made little or no active attempt to learn the language" and/or "limited L2 instruction, especially classroom-only instruction with instructors who have a strong L1 accent" (Best and Tyler, 2007: 34). On the other hand, SLM focuses on L2 learners who are currently actively learning an L2 for functional and communicative purposes that far exceeds those pertaining to educational or classroom value. Thus research on the SLM tends to focus more heavily on L2 learners with high levels of proficiency. This is a differentiation worth noting between the models. The new model proposed in this research does not aim to conflate models, and in fact, the new model recognizes these differences.

that these informants are typically born in Korea[25] and have had prior residency in the country, they consider Korean their L1. Many of these informants have also received formal instruction in Korean and have attended school in Korea. One particularly noteworthy feature shared by informants in this group is that many of these informants also attended an international school and thus have had a language upbringing characterized by mixed input. Though their level of proficiency in English is relatively high, a foreign accent can be detected in their English. They use predominantly Korean in everyday interactions, whether in the home or with social groups, unless English is required such as in the classroom setting or with friends who may not speak Korean. For informants in this particular group, we expect their Korean vowels to remain unaffected and resemble the vowels given in Yang's measurements, as evidenced in Figure 4, while we expect their English vowels to be partially developed. Many of their English vowels will naturally deviate from the English vowels seen in Figure 3 since English is their L2 and many of the sounds may not have been fully acquired. As an exemplar I will consider Informant C.

4.4.7 Discussion of Informant C

Informant C was born in Monterey, California and raised in a variety of different locations internationally.[26] She reports having lived in Seoul, Korea, Moscow, Russia and Kazakhstan. She attended International schools in each of the aforementioned countries. Informant C also reports having attended all of elementary school, 2 years of high school as well as a few years in Kindergarten in Seoul, Korea, which suggests that she received much of her pre-college formal education in Korean. Both her mother and father report Korean to be their

[25] Depending on the informant, some were born in the US. The key is that despite having been born in the States, the first language spoken to them was Korean and in most cases, families relocate to South Korea soon after birth.
[26] Informant C explains that her father was a Korean diplomat, which often required frequent travelling and relocation to various countries.

native languages, and was also the first language used in the home. Thus, even though she was born in the States, Korean is still her L1 since it was used in the home with her family all throughout childhood as well as adolescence and currently even into young adulthood. In fact, Informant C also reports that she has been in Korean speaking communities all her life, indicative of her frequent usage of the Korean language even in social settings when with friends. She also describes Korean as the dominant language used when with family and friends. Likewise, she reciprocates the language input by using predominantly Korean in her exchanges with friends and family, which suggests that there is rarely ever any need to transition between English and Korean since she is usually with other Korean speakers with the exception of the classroom setting, which includes many English-speaking students.

Given this background, as mentioned earlier we expect Informant C's Korean vowels to be intact and strong in semblance to the vowels displayed by Yang's female Korean speakers. Instead, we find interesting deviations that share greater insight into the seemingly unexpected commonalities shared by both Informants C and E. We see similar trends in Figure 17 (below), which show Informant C's English Korean plotted on formant chart.

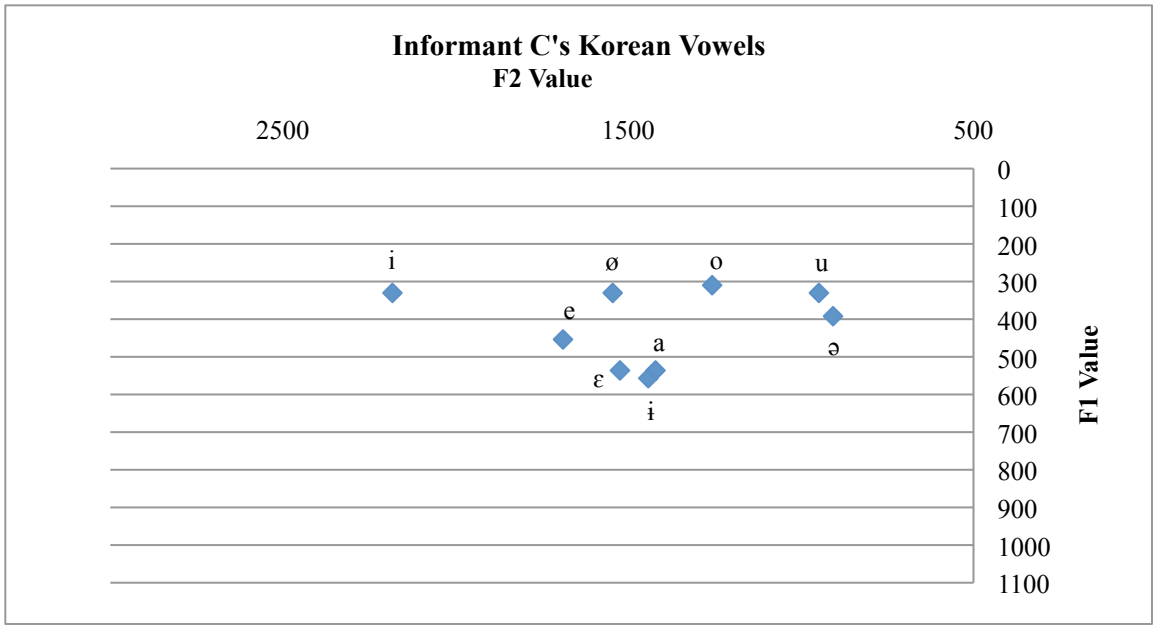

FIGURE 17. Informant C's Korean vowels.

Many of Informant C's front Korean vowels have shifted to the back. This shift is also noticeable in her front cardinal vowel /i/ which has also shifted in a location more usually found in a front-central vowel. This shift also appears to set the precedence for all other vowels that seem to undergo drift towards the back vowels. Though there is no noticeable collapse in vowels as in distinct cluster formations; in fact, many of the central-back vowels appear to preserve some proximity relative to one another, there is still collapsing of certain vowels, such as the /a, ɨ, ɛ/ vowel sounds. Furthermore, the /ə/, further back than expected, appears to be collapsing with her /u/. These findings are unexpected due to their deviations; however, these findings could help lend themselves to support the theory that representations in the L1, which is Korean in this particular case, are naturally intended to shift when emerging L2 sounds in English develop. Therefore, L2 appears to have an effect on existing L1 representations. Figure 18 (below) depicts Informant C's Korean vowels along with Yang's measurements for his Korean speakers.

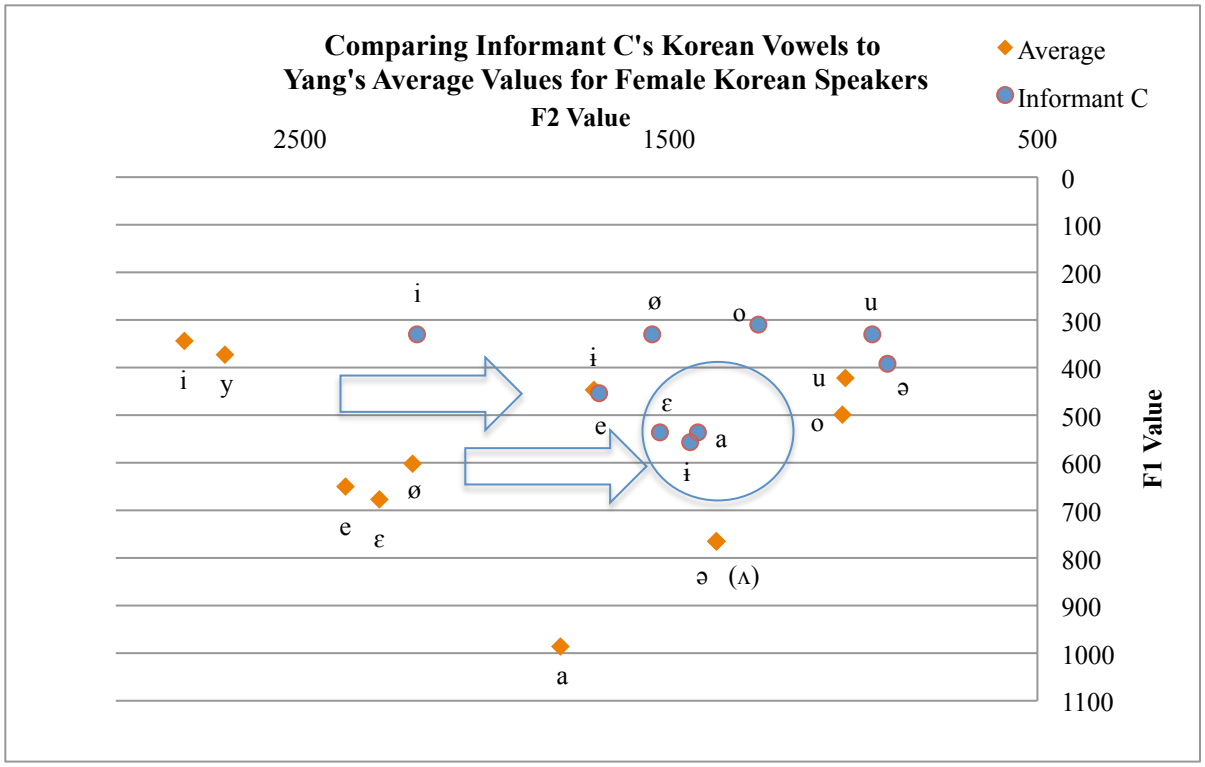

FIGURE 18. Comparing Informant C's Korean vowels to Yang's average values for female Korean speakers.

The arrows in Figure 18 indicate the direction in which the shift is occurring, predominantly towards the back. The circled vowels represent those experiencing significant collapsing. Interestingly, Informant C's /e/ actually appears to be produced in a manner most typically associated with the production of /i/ as evidenced in its collapse with Yang's measured /i/.

As expected, Informant C's English vowels differ from expected values, and a significant shift towards the back can be seen in Figure 19 (below). Vowels that should be front are rematerializing in the central-back region. In fact, Informant C seems to reveal a pronounced shift, more so than the other informants who demonstrated less observable shifts in vowels. Most notable is that there seems to be no relatively front English vowels in Informant C's inventory. Most notably amongst these front vowels are /i, e, ɛ, æ, ɪ/ as they appear to be experiencing a shift in placement, moving towards the back.

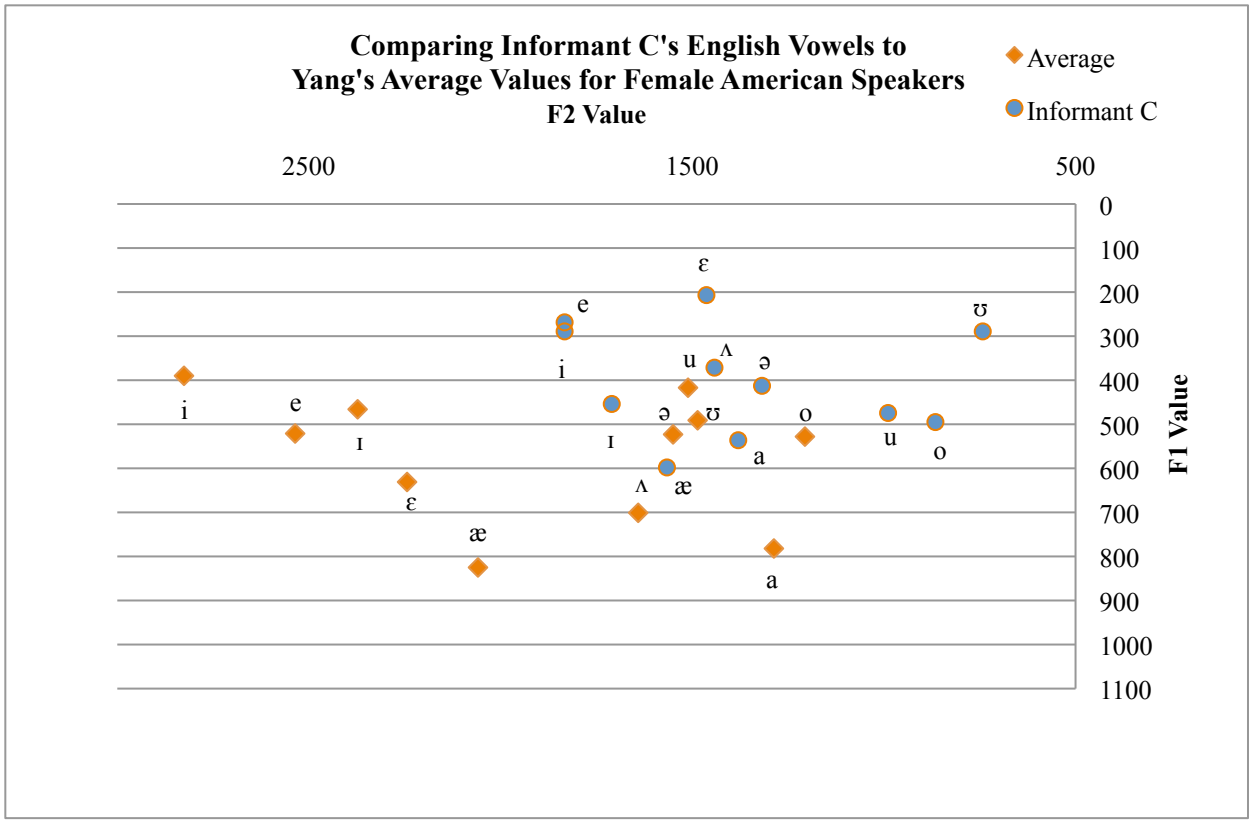

FIGURE 19. Comparing Informant C's English vowels to Yang's average values for female American speakers.

Informant C's English and Korean vowels, both sets of which are presented on a formant chart in Figure 20, also provide a telling story. Vowels in both languages cluster in the same region as her central-back vowels, with a few clustering with her back Korean vowels. Similar to her English, most of her Korean vowels that should be front appear to have resurfaced in the back, which suggests that collectively, there appears to be no relative vowel that can be considered a proper front vowel in her inventory, save her /i/, which is actually more front-central, than front. As a whole, there is a significant shift towards the back that characterizes all

of her vowels.

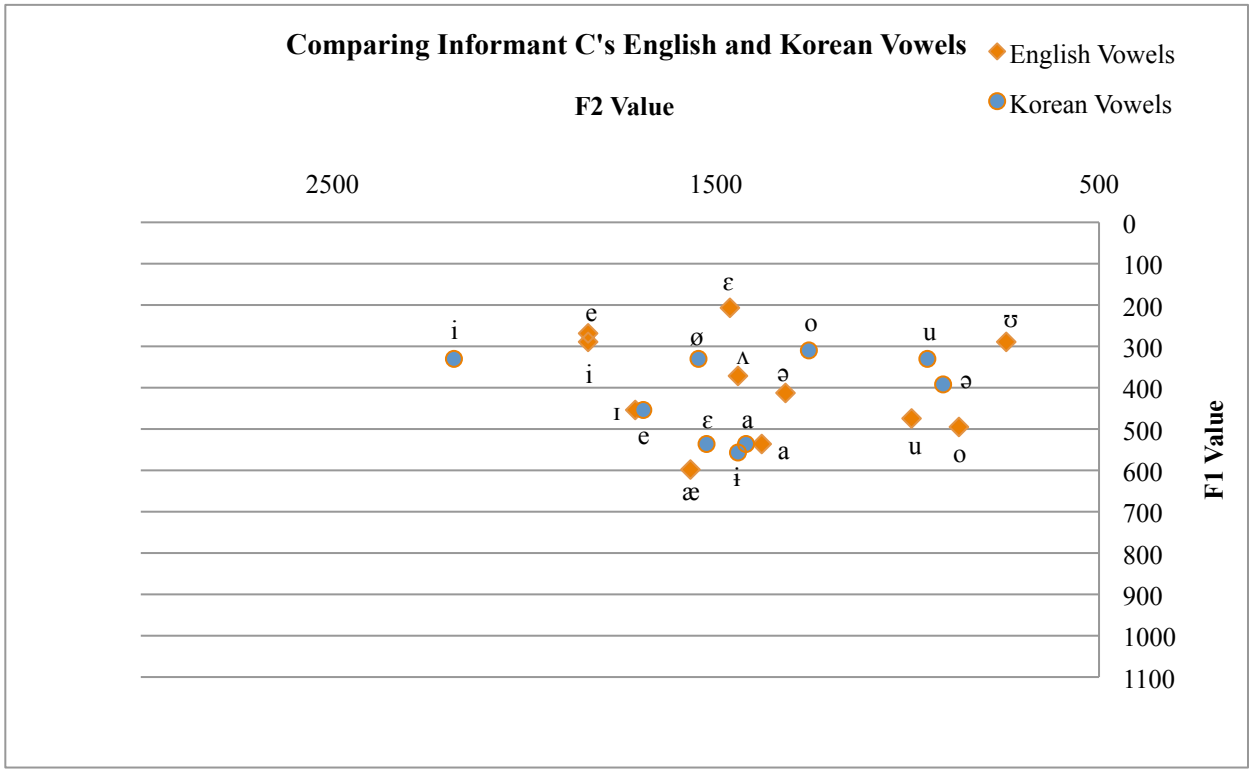

FIGURE 20. Comparing Informant C's English and Korean vowels.

Informant C's vowels, as much as they are expected to be partially developed sounds, are in many ways also unexpected in terms of their actual placement. A number of factors could be at play in Informant C's vowel phonemes, all of which support the potential for a new model that proves more encompassing of our findings. To explain Informant J's shift I posited that her emerging Korean L2 categories were initiating the shift in her L1 English vowels. The reverse could be applied here; it could be the case that Informant C's developing representations in English are forcing her L1 categories in Korean to shift. Even more telling is the close proximity of all of her vowels, collectively, as we seen in Figure 20. Both her English and Korean vowels are all well within distance of one another, perhaps suggesting that not only were L1 categories in flux, but her L2 categories were generally more prone to influence by the L1 and thus

naturally assimilated to existing sounds and fossilized in close proximity of her Korean vowels. To help quantify these observations, the Euclidean distance between these vowels have been calculated and then compared to the distance found between the vowel measurements given by Yang.[27] This is particularly helpful in our following discussion on her collapsing English /ɪ/ and her Korean /e/.

Thus, many of Informant C's English vowels are likely to have borrowed traces of Korean sounds. One particular instance, which is especially noteworthy, is the placement of her English /ɪ/ in relation to her Korean /e/. Not only have these vowels completely collapsed into one another, but in fact, they appear to be overlapping one another, perhaps indicative of her English /ɪ/ perhaps assimilating to an existing category, which in this case happens to be her Korean /e/. Calculating the exact distance between Informant C's English /ɪ/ and her Korean /e/ yields a distance of 21, interestingly revealing that the F1 values for both vowels are the same, measuring at 453 Hz. In comparison, the distance between the English /ɪ/ and the Korean /e/ for Yang's informants is 184.04, significantly larger than the distance found between Informant C's vowels. This supports the idea that Informant C's English /ɪ/ and her Korean /e/ have collapsed.

Even more so, English vowels, /e/ and /ɪ/ are actually quite close in proximity to one another. Thus, it could be that since /ɪ/ is unavailable in the Korean language, a close comparable sound available in Korean is the /e/, which is actually lower than the English /e/. This is further evidence of the process by which our bilingual informants demonstrate a natural tendency to produce foreign sounds with existing sounds in the L1. Keeping the Perceptual Assimilation Model in mind, it would be additionally insightful to study whether our Informant C is in fact

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[27] The formula used was $\sqrt{(x_2-x_1)^2 + (y_2-y_1)^2}$, where X_2 is F2 value for the first set of vowel measurements, X_1 is the F2 value for the second set of vowel measurements, Y_2 is the F1 value for the first set of vowel measurements and Y_1 is the F1 value for the second set of value measurements.

capable of discerning these various sounds.[28] In addition to PAM, the Speech Learning Model is also applicable as it could be that Informant C is modifying her Korean /e/ to produce the English /ɪ/. Thus both models play a role in beginning to tease apart Informant C's findings.

On the other hand, we could also speculate that since we expect her English vowel categories to be developing, these emerging representations could be pulling her Korean vowels and causing them to collapse into smaller clusters of back vowels. Regardless, Informant C offers an insightful case study on ways in which vowels from both languages on a bilingual spectrum can affect one another in more than one given direction – and that in fact, is the beauty of bilingualism, vowels that are constantly in flux and transition as they borrow sounds from respective languages to finally fossilize as hybrid and constructed vowels in the individual's inventory. Thus individuals are able to produce sounds not only from both languages, but sounds that are unique to the individual, unique phonemes, which finally leads us to our final, and most important group of informants.

4.4.8 GROUP 4 – Characteristics

Group 4 is consists of bilinguals who demonstrate a working knowledge of both Korean and English, they can claim either language as their official L1. While they show relatively high proficiency in both languages, they show complete mastery in neither one, thus make it a challenging to assign one language the L1 over the other. Both languages, categorically, reside in a gray area for languages that are neither the L1 nor the L2. Subsequently, speech production of both English and Korean tends to be heavily accented. This is largely attributed to their upbringing in immigrant families. Depending on the informant, she was born in Korea, then

[28] Though this is outside the scope of this paper as it deals specifically with production of speech, it would be worthwhile to study whether her Korean /e/ and her English /ɪ/ are perceived to be the same. The intersection of production and perception could help reveal further insight into our research, but at the moment, remains outside the breadth of this study.

moved to the US at an early age and raised in the US, or born and raised in the US. Korean was the first language used in the home, at the time, making it their L1. However, because the move took place very early on during childhood, Korean is only partially their L1 because the move occurred before a complete set of L1 representations could be formed.

Before further discussion, it is important to note that vowel categories tend to form fairly early on in childhood. Informants from Group 4 will help to articulate the point that vowels are, in fact, unstable, and were unstable during the time of the immigration process. Jusczyk (1997) examined the initial capacities that infants possess to discriminate and categorize sound, and he argued that these capacities actually evolved over time as infants developed new experiences and increased exposure to L1 input. This also corroborates Flege's (1993) proposition that the mechanisms used during L1 acquisition during childhood change during adulthood. Chang also argues that vowels change throughout adulthood (2010). In all, Jusczyk, Flege and Chang help build the argument that vowels are constantly susceptible to changing. In light of this, informants in Group 4 also help to support my theory on the production of melded vowels as a result of constantly interacting vowels that are ever changing in response to these interactions.

Thus, with partially developed sounds in Korean in tow, these informants moved to the US and were placed under circumstances to learn English, at which point English also became a comparable rival for the role of the L1, though still their L2 in many ways. Effectively, those from immigrant families were often placed under circumstances that required them to learn English in order to serve as translators or function in some capacity as liaisons of communication for their families. Therefore, emerging English phonemes were quickly put in immediate contact with also still developing Korean phones. As for our other informants in this same category who were born and raised in the US, they, too, descend from immigrant families. Korean remains in

consistent use in the home. English is also used frequently outside the home, as is Korean should they be with friends or people who identify with the Korean and Korean-American communities. While afforded the opportunity to speak both languages, both are produced with detectable foreign accents. These informants were educated in the US in English-medium schools, though they still may have attended formal classes to learn Korean. Based upon their production of both English and Korean, it seems that they adopt neither one as their "true" L1 as evidenced by the foreign accent in both. In fact, the independent evaluation by native speakers of Korean and English gave this group an average fluency score of 3.6 in Korean and 4 in English.

Given this background, informants in this particular category are expected to reveal vowel sounds pertaining to both languages to deviate from Yang's outlined phonemes. We expect this because neither language was fossilized with a complete sound set of correct vowel pronunciations and was, in fact, interrupted by the onset of the other. To demonstrate, we will study yet another exemplar that represents our informants in Group 4. I will discuss the findings of Informant D.

4.4.9 Discussion of Informant D

Informant D was born in Seoul, Korea and was raised in Korea for the first 3-4 years of life, at which point she moved to the States, and has since then resided in the US. She reports Korean and English to be both of her native languages. Korean is the L1 for both her mother and father, and thus it is the language that is used most frequently in the home since neither her mother nor father feel comfortable speaking English or demonstrate a high enough proficiency in English. An important detail to consider is that while Korean was Informant D's first language, she reports a change in language at 4 years of age, transitioning from Korean to English. She reports that her mother, father and grandparents use only Korean with her, while friends and

siblings tend to use mostly Korean though they may alternate with English. Likewise Informant D reciprocates the language input depending on the individual – with immediate family she will only use Korean while with friends, though she can use English, will tend to use Korean, while interestingly, she reports that with her siblings she employs an equal amount of both English and Korean. Hence, her everyday interactions will testify to her bilingual background, using and receiving mixed input. Additionally, though she has never been formally educated in the Korean language and has predominantly attended schools in which English is the main medium of testing, she reports having taken multiple Korean classes at Wellesley.

Informant D has a natural tendency to code-switch[29] between languages, demonstrating a natural tendency to utilize both languages, especially when her thoughts can be better articulated in one language due to cultural differences, or because social interactions with certain Korean friends trigger such actions. This particular phenomenon of code-switching could possibly be a by-product of her bilingualism – utilizing both languages in everyday conversation could actually serve a compensatory role since she demonstrates partial fluency in both languages. Subsequently, due to the almost seamless nature of transitions between English and Korean, the foreign accents we detect in her speech production could be essentially a physical manifestation of her inability to "turn off" one language as she "turns on" another. After all, that could be in fact the trademark of a perfect bilingual – the ability to go between languages without awkward transitions while still maintaining a level of distinction. But as discussed earlier, bilingualism is on a spectrum, and perhaps the very nature of physically changing from one language to another

[29] Code-switching is the concurrent use of more than one language in conversational interactions. Thus multilinguals will often use features of multiple languages in everyday conversation. The exact social factors motivating code-switching remains outside the breadth of this study, but is still interesting to consider when looking at Informant D's ability to use many languages simultaneously in day-to-day interactions and whether this can be attributed to her incomplete mastery of both languages.

should also be counted on a spectrum. For those reasons, Informant D not only provides a particularly compelling case study, but also a chance to revisit theories on bilingualism.

Informant D's English are especially insightful as illustrated in Figure 21. There is clearly visible clustering of vowels, particularly the clustering of almost all of her central and central-back vowels.

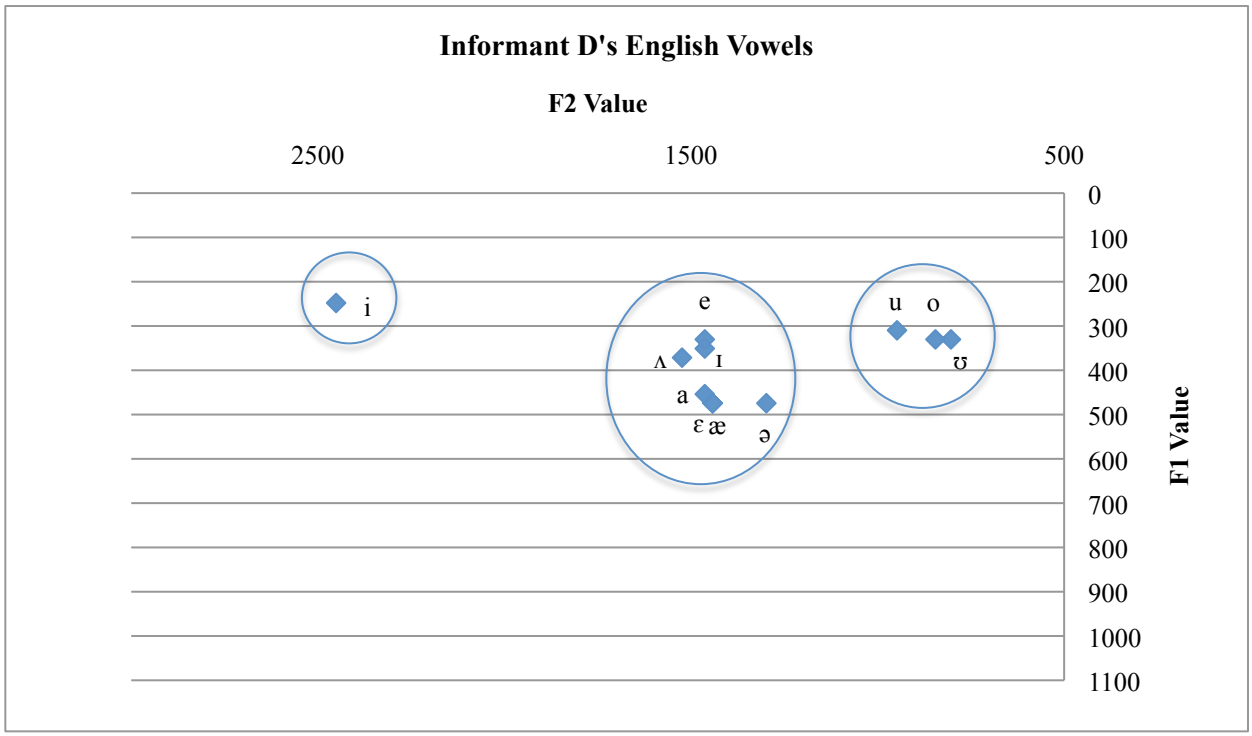

FIGURE 21. Informant D's English vowels.

Immediately, as initially expected, the English vowels deviate from Yang's measured formant values. Surprisingly, however, is the exact nature by which her English vowels have shifted. In fact, in relative comparison to our other participants, we notice significantly more clustering in our vowels, so much so that all her vowels appear to fall into 3 groups of natural clusters. The most dramatic of shifts is the clustering of essentially 7 of her vowels, vowels that are all of varying manners of articulation and sample from different ranges. These vowels that have drastically clustered into a dense cluster are /e, a, ɪ, ʌ, ɛ, æ, ə/. In fact, there is noticeable shift in

all her vowels to the back, an occurrence we have been observing throughout this research. Even her cardinal vowels /i/ and /u/ have noticeably shifted in expected placement.

Informant D's case provides an especially interesting narrative in terms of vowel development. Informant D's vowel placement provides insight into the effects of learning conflicting languages, especially when the learning process of the L1, or what was originally perceived to be in the role of the native language, is incomplete. There are obvious pronunciation errors in both the L1 and the L2, and we would like to account for this by proposing that our Informant D is replacing the required vowels for correct pronunciation with her own melded vowel. This melded vowel is a result of all 7 of her collapsed vowels melding to construct one amalgamation of a vowel sound. We predict that this particular sound borrows features from each of the 7 collapsed vowels, hence producing a sound that is characteristic to Informant D. Thus because her vowels /e, a, ɪ, ʌ, ɛ, æ, ə/ have failed to achieve complete acquisition or remain at a recognizable distance from each other, instances in which one of those vowels is necessary actually results in a mispronunciation, because she is replacing the necessary vowel with a constructed vowel.

Interestingly, Informant D's Korean vowels appear to be relatively well formed, with many of her vowels spaced accordingly in relation to other vowels, as evident in Figure 22.

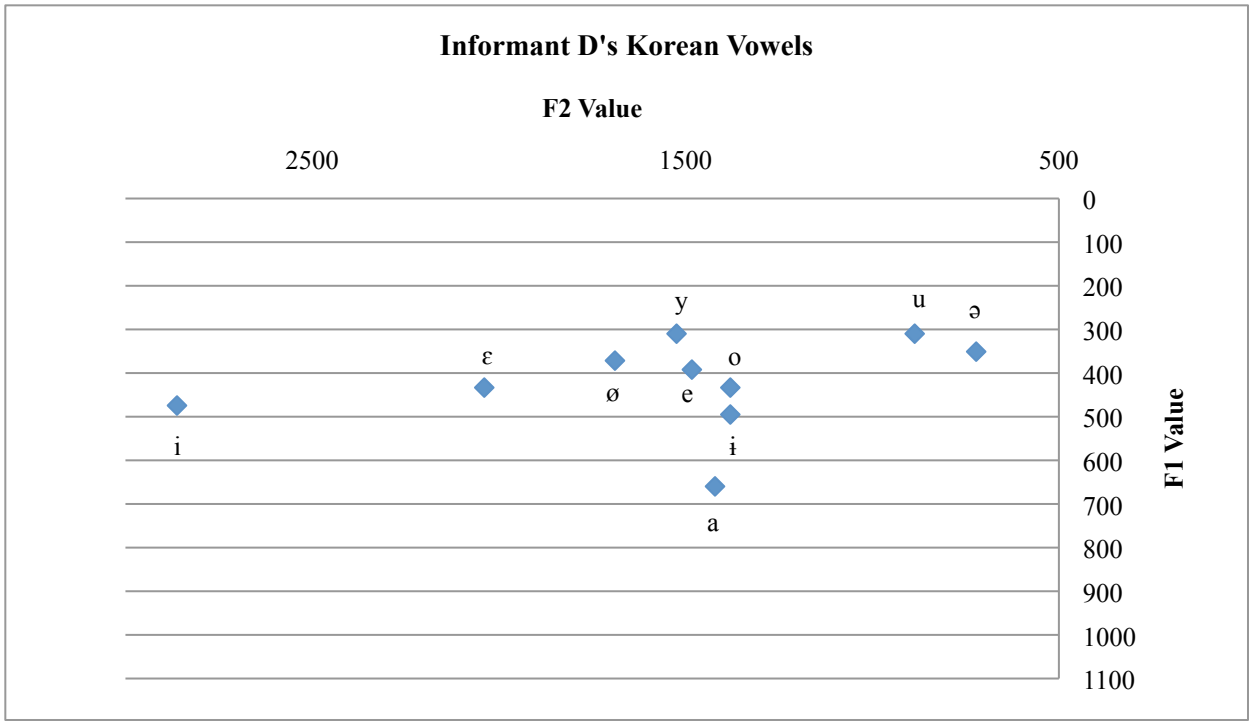

FIGURE 22. Informant D's Korean vowels.

There is no significant clustering in any of her Korean vowels. In fact, when compared to Yang, her vowels with the exception of a few resemble for the most part the measurements given by Yang. The most noticeable of shifts are observed in her /y, e, ɛ/ as evident in Figure 23 (below). The arrows indicate the degree of separation from expected values and Informant D's measurements.

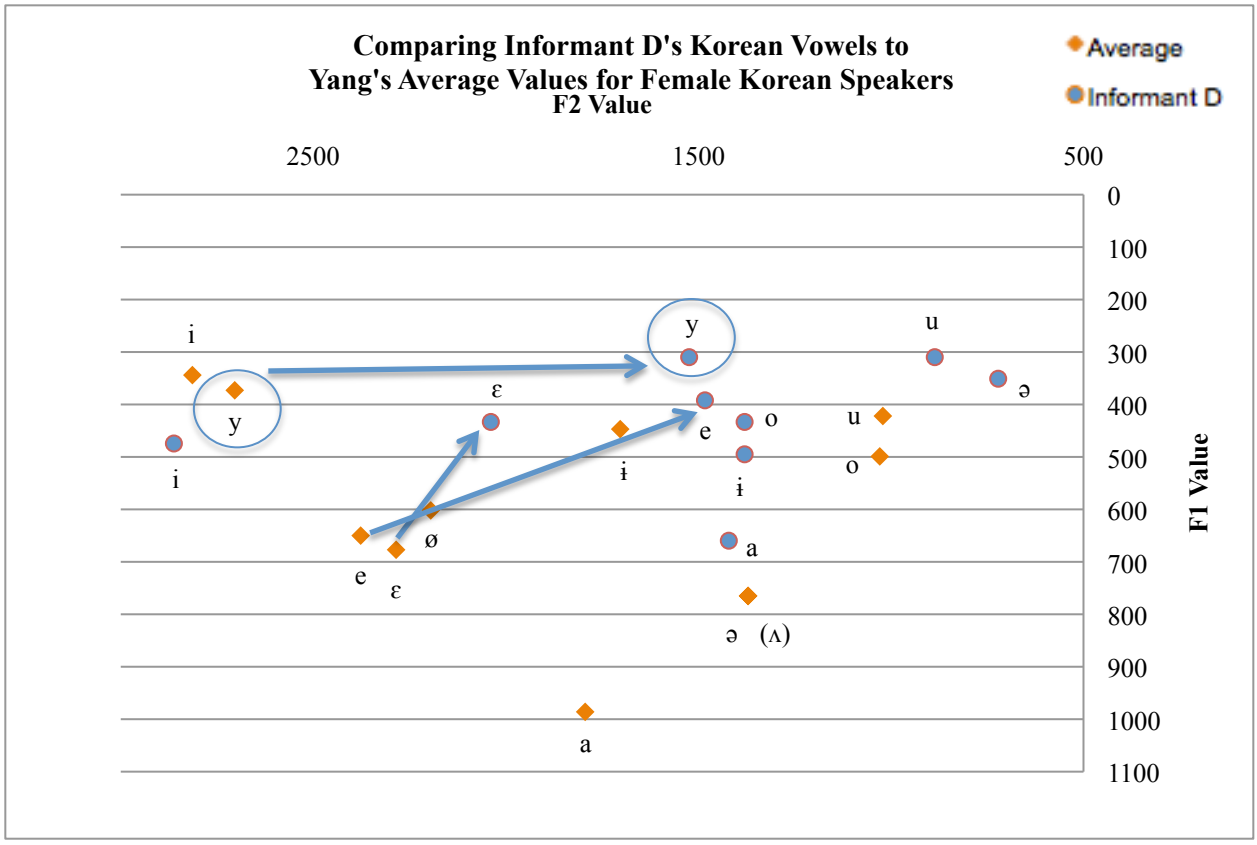

FIGURE 23. Comparing Informant D's Korean vowels to Yang's average values for female Korean speakers.

This is most likely the case because Korean was, in fact, the first language used in her home, and used extensively for the first four years of her life. Additionally, many of her vowels also shifted again, presumably to place, when they resurged later on in late adolescence and early adulthood as she took formal classes at Wellesley. More importantly to these findings is the detail that Informant D also continued to use Korean in the home to some degree even after she started to learn English upon immigration. Therefore, it would be likely that even if her vowels shifted out of place initially, they were able to adjust accordingly, or because since she consistently used the Korean language over the years, the vowels themselves experienced little shift in the first place and that the major shifts are really attributed to emerging English vowels in her inventory. This also corroborates Flege's findings (1999, 1995) that languages are more easily reacquired in later

life if people are given early exposure to the language, which is very much the case for Informant D since she is now considered a heritage learner of Korean.

The findings from Informant D's data are also especially interesting because they trigger reconsideration of many of the models and theories discussed in earlier sections. First, these findings lend themselves well to the Merger Hypothesis, proposed by Flege (1987), which states that the collision of phonetic properties of phones that are similar in both the L1 and L2 are bound to have effects not only on the L2, but on the L1 as well. Additionally, as mentioned earlier, the equivalence classification also posits that if one is unable to form a new category for an L2 sound, and instead maps it onto an existing L1 sound, one will be unable to pronounce the L2 sound authentically.

However, it is also important to consider the converse relation. When existing sounds and emerging sounds come into contact in a bilingual environment, there may also be a possibility that L1 sounds try to map onto L2 sounds, thus resulting in skewed L1 phonemes. The emerging L2 representations could potentially overwhelm existing sounds, which also invites us to consider the possibility of whether certain sounds are perhaps more "potent" in effect than others, regardless of whether the sound pertains to the L1 or L2. If the sound is so unique or so different, perhaps it causes L1 sounds to reorient and readjust to accommodate for these striking L2 sounds. These various considerations bring to light the shortcomings of siding with one particular model that advocates for one specific direction of influence, hence the reason to revise existing models to take into account both directions. It would be more fruitful to construct a model that encompasses the effects of L1 on L2 as well as the effects of L2 and L1.

We have seen in the discussion of Informants J, D, C and E that trying to brand our collective findings to fit within the confines of one model that also proposes one way of

influence fails to account for other findings. Therefore, I propose a two-way model suggesting that not only can L1 influence L2 development and thereby production, but that L2 is capable of the same, influencing L1 and thereby production, which ultimately leads to the conclusion that all vowels, whether it belongs to L1 or L2, are in flux and prone to change.

CHAPTER 5 – CONCLUSION & FUTURE DIRECTIONS

My study has shown that existing models L2 acquisition do not fully explain the result of an interaction between the L1 and the L2, particularly in Korean-English bilinguals. These findings suggest a need for revisions in existing models of L1 and L2 acquisition. I have shown that current models only account for interactions between the L1 sounds and the emerging L2 sounds from one direction. Though my research does support these standard models, my findings also suggest that a more comprehensive model is required to account for both directions – the effects of L1 on L2 as well as the effects of L2 on L1. This model will help account for pronunciation errors in the L1, which are more unusual than pronunciation errors that are found in L2. These occurrences of L1 pronunciation errors provide further reason to modify current models mapping language acquisition.

Further, this detailed study of vowel production in Korean-English bilinguals also shows that pronunciation errors in the L1 can be traced to production of melded vowels, which occur as a result of vowels clustering and/or collapsing. My findings show that vowels in both English and Korean can cluster and eventually collapse into one another to produce one vowel sound, a phoneme that is unique to that individual. Thus, these errors leading to the perception of a foreign accent occur because melded vowels are used in place of the required vowel, which has only been partially acquired into the individual's phoneme.

I also introduced the bilingual effect, the prevalence of which suggests that certain effects on vowels are simply inherent to bilingualism, again leading to the conclusion vowels are naturally vulnerable to outside influence.

One possible way to account for pronunciation errors in both the L1 and the L2, but especially so in the L2, is by using Krashen's Input Hypothesis and possibly positing that

bilinguals are reutilizing their own incorrect pronunciations as input and perceiving this input to be correct, thereby eliminating any opportunity for correction. Krashen (1985) argues that simply speaking in the target language does not result in complete acquisition. He contends the commonly held belief that language learning of acquisition is contingent upon speaking abilities. Instead, he proposes that comprehensible output is the outcome of language acquisition. Thus, if mispronunciations are rarely corrected early in the acquisition process in the home, the family could speak a language that is different from the target language, and the individual has a diminished opportunity to produce comprehensible output. This could be a possible future direction in which my research could lead, potentially yielding more interesting findings.

In all, this study shows the importance of challenging the standard assumption that vowels categories, particularly those of the L1, are permanent. In fact, given this two-directional interactions between the L1 and the L2, I argue that all vowels, regardless of the state of bilingualism, are prone to change. In fact, that is the significant understanding of bilingualism to be on a spectrum: vowels are in constant transition, speech production is in constant transition, and the individual as a bilingual is in constant transition.

APPENDIX A

Learner Language Background Questionnaire (Developed from Professor Sun Hee Lee)

Name _____ Date _____

Age _____ Year of Birth:

Gender_____

Nationality:

Native Language(s)_____ School Name

Course Level in Wellesley

I. Language History

1. Where were you born and where did you grow up?

City and Country:

2. How long have you been in U.S? Years ___ Months

3. What is your mother's native language?

4. What is your father's native language?

5. Have you visited Korea before? Yes / No
If 'Yes', how many times have you been there and how long (total) did you stay?
_____Times _____Months

6. How long have you been studying Korean at Wellesley? _____ Years _____ Months

When did you start to learn Korean in Wellesley: Year _____ Month _____/ Age _____

Which Korean classes have you taken so far? (Including current semester).

7. Have you studied Korean in a formal class setting before you attend at Wellesley? (Korean class at school, Hangeul Hakkyo, Saturday School, etc.) Yes / No

If 'Yes', what courses and how many quarters/semesters have you taken?

8. Can you speak any other foreign languages? Please list them in the order of fluency.

Language1: _____ Language2: _____ Language 3:

9. Have you been in Korean speaking communities? Yes / No

If' Yes', How long? _____ Years _____ Month Where?_____

10. Was Korean your first language home? Yes / No

If 'Yes', please go to Question 10.
If 'No', please move to Question 13 in

II. Self-Assessed Proficiency.

N.B Please answer Questions 11-13 ONLY when your answer to Question 10 is 'Yes'.

11. How old were you when you started to switch from Korean to your native language X. (X means your native language) Age:

12. Estimate how often the following people use Korean and your native language X when they speak to you. (For English native speakers, X is English).

a. Father

Always X	Mostly X	Equal	Mostly Korean	Always Korean	NA	

b. Mother	Always X	Mostly X	Equal	Mostly Korean	Always Korean	NA	
c. Siblings	Always X	Mostly X	Equal	Mostly Korean	Always Korean	NA	
d. Friends	Always X	Mostly X	Equal	Mostly Korean	Always Korean	NA	
e. Grandparents	Always X	Mostly X	Equal	Mostly Korean	Always Korean	NA	

13. Estimate how often you use English and Korean when you speak to the following people. (For English native speakers, X means English)

a. Father	Always X	Mostly X	Equal	Mostly Korean	Always Korean	NA	
b. Mother	Always X	Mostly X	Equal	Mostly Korean	Always Korean	NA	
c. Siblings	Always X	Mostly X	Equal	Mostly Korean	Always Korean	NA	
d. Friends	Always X	Mostly X	Equal	Mostly Korean	Always Korean	NA	
e. Grandparents	Always X	Mostly X	Equal	Mostly Korean	Always Korean	NA	

II. Self-Assessed Proficiency

14. Please provide your self-assessment of the Korean language skills. (1 is the lowest 5 is the highest)

	Low ←				→High
Speaking	1	2	3	4	5
Listening	1	2	3	4	5

Reading	1	2	3	4	5
Writing	1	2	3	4	5

III. Motivation

15. Please estimate the importance of the following reasons for learning a language. Please add more items of your own, if necessary, in line i.

	Strongly Disagree	Disagree	Somewhat Agree	Agree	Strongly Agree
a. Connect with culture					
b. Improve speaking ability					
c. Better career opportunities					
d. Communicate with relatives					
e. Get an easy A					
f. Visit country					
g. Improve reading and writing					
h. Fulfill a language requirement					
i. Other (specify) _____					

I hereby declare that all the information provided above is accurate to the best of my knowledge.

Signature_____

I understand that this questionnaire may be used anonymously and in confidence at some point in the future to compile group (but not individual) profile statistics for research purposes. I hereby consent to such use of the above information and release it for these purposes only.

Signature_____

Date _____

APPENDIX B

Individual Informant Vowel Charts

INFORMANT A

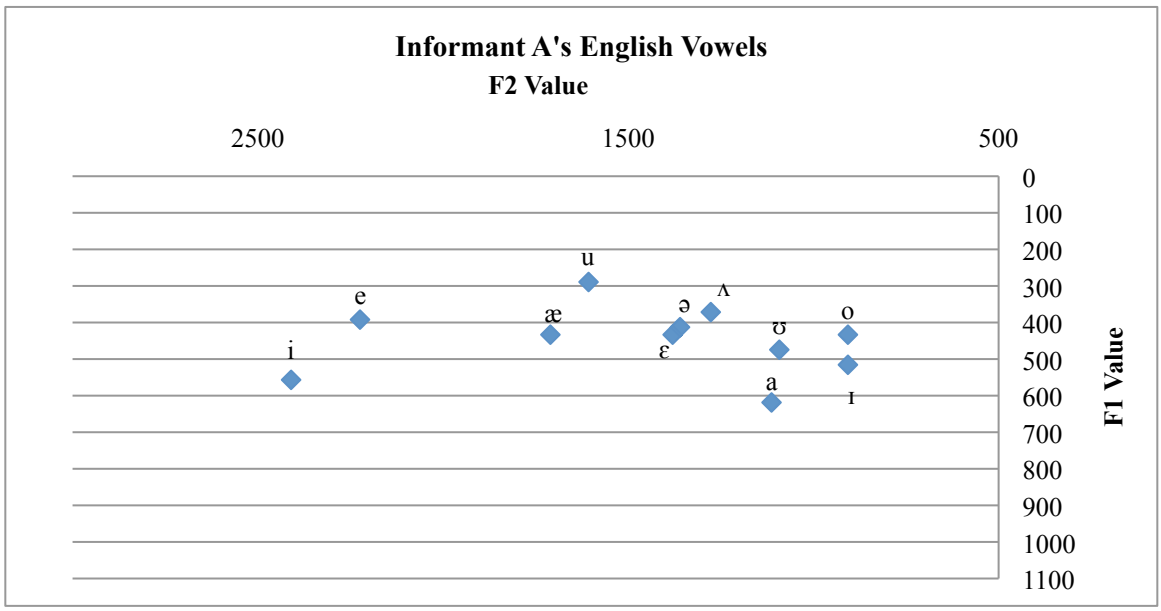

FIGURE 24. Informant A's English vowels plotted using F1 and F2 measurements for each vowel.

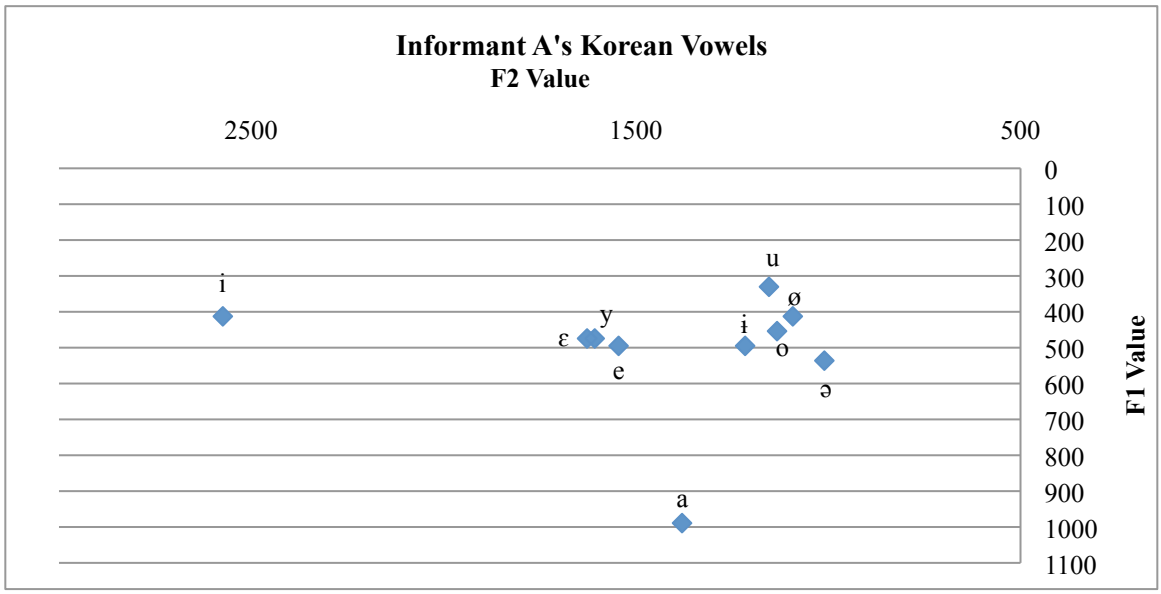

FIGURE 25. Informant A's Korean vowels plotted using F1 and F2 measurements for each vowel.

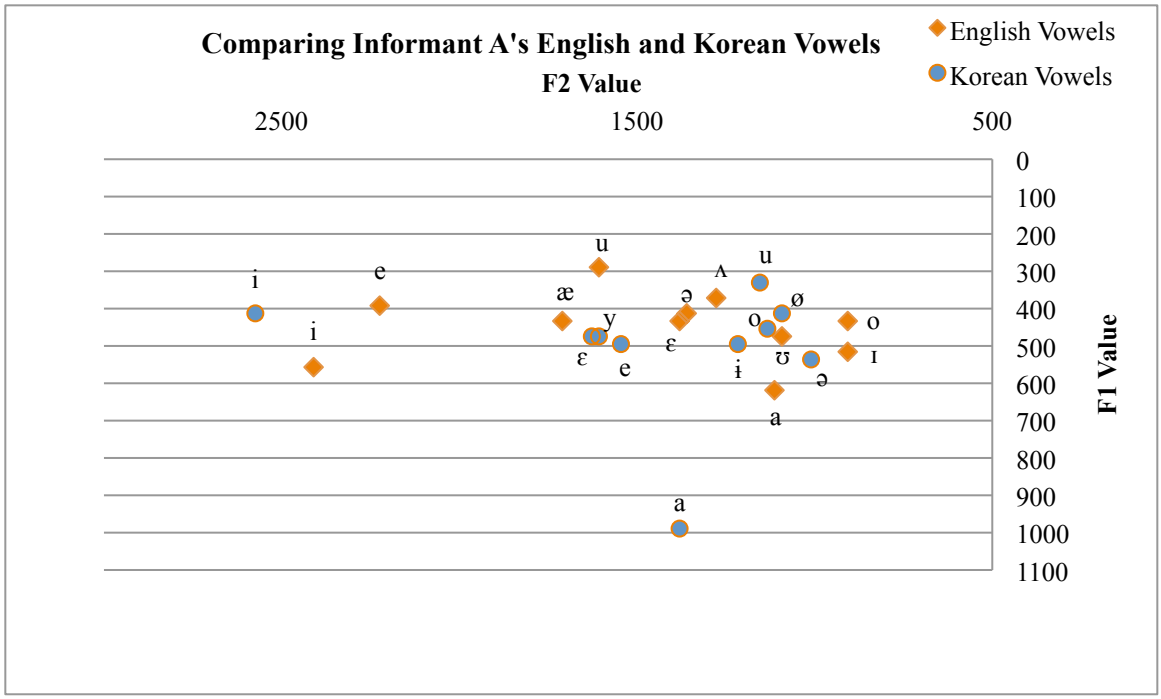

FIGURE 26 Informant A's English and Korean vowels mapped overlaid on top of one another using F1 and F2 measurements for each vowel.

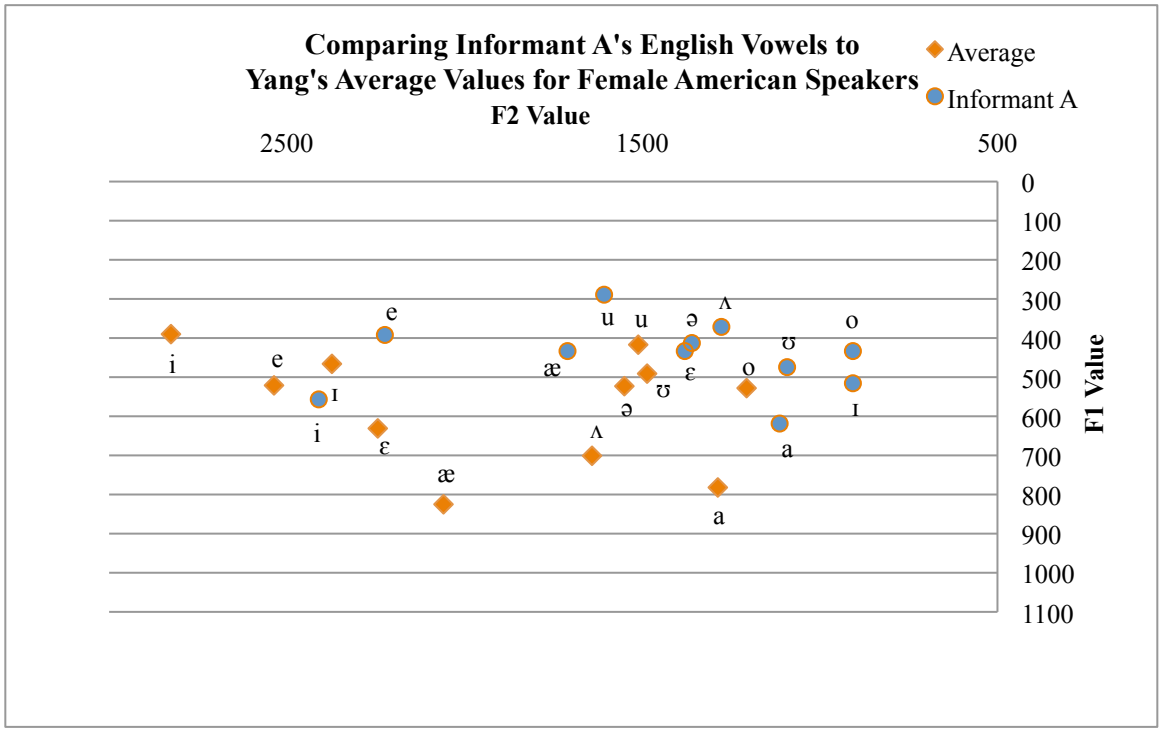

FIGURE 27. Informant A's English vowels plotted using F1 and F2 measurements overlaid on top of the vowel measurements given by Yang's average values for female American speakers.

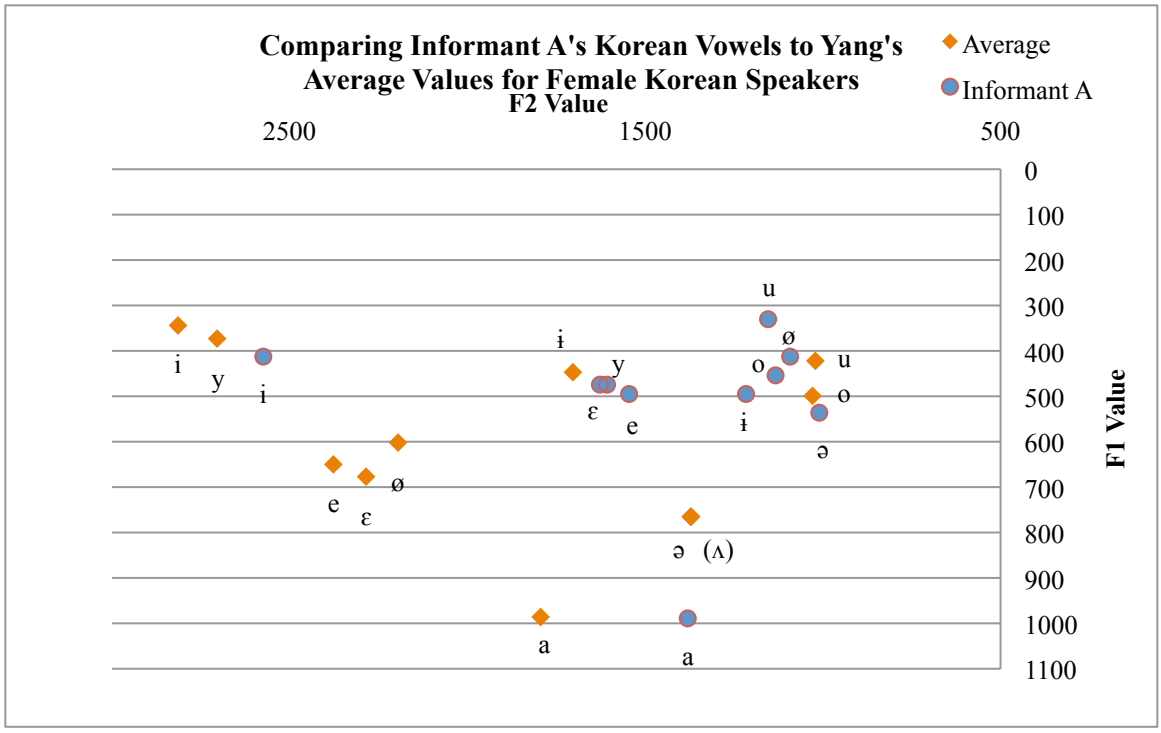

FIGURE 28. Informant A's Korean vowels plotted using F1 and F2 measurements overlaid on top of the vowel measurements given by Yang's average values for female Korean speakers.

INFORMANT B

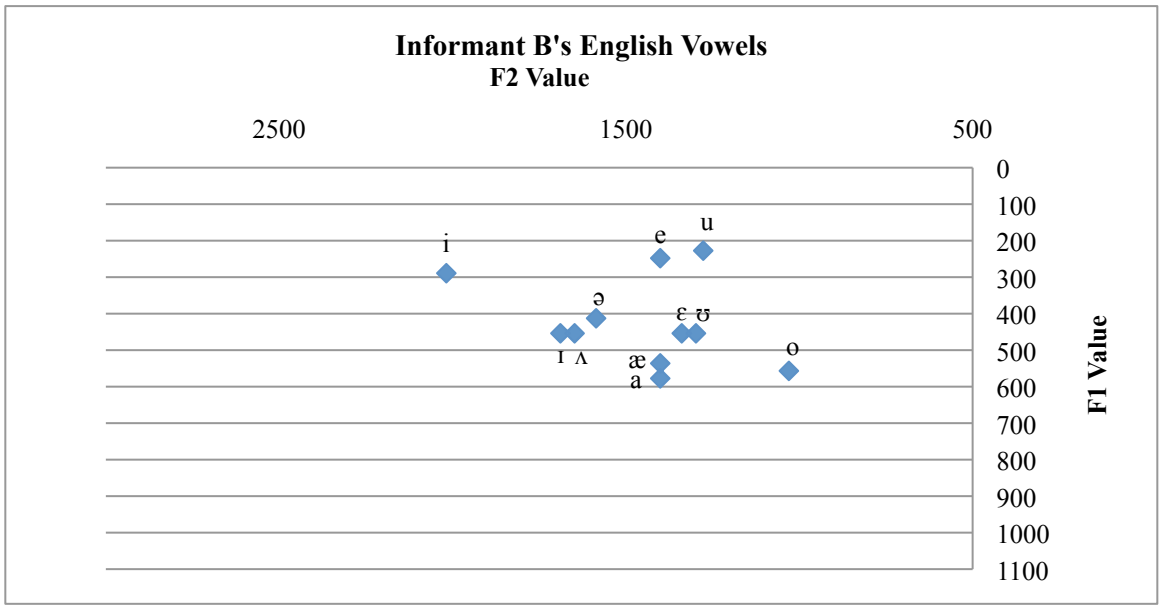

FIGURE 29. Informant B's English vowels plotted using F1 and F2 measurements for each vowel.

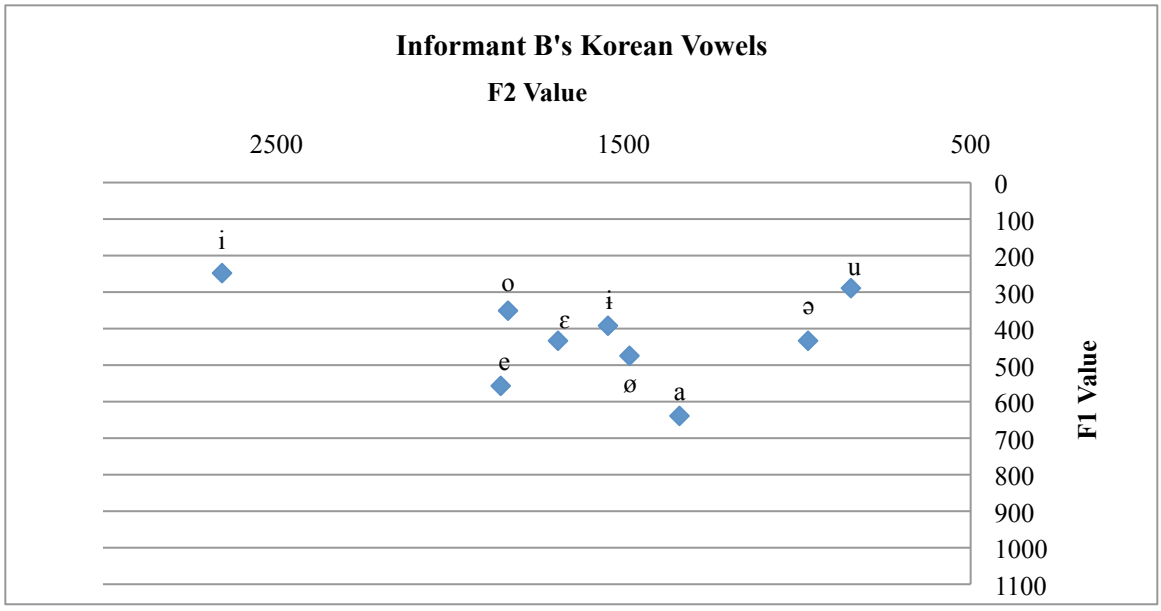

FIGURE 30. Informant B's Korean vowels plotted using F1 and F2 measurements for each vowel.

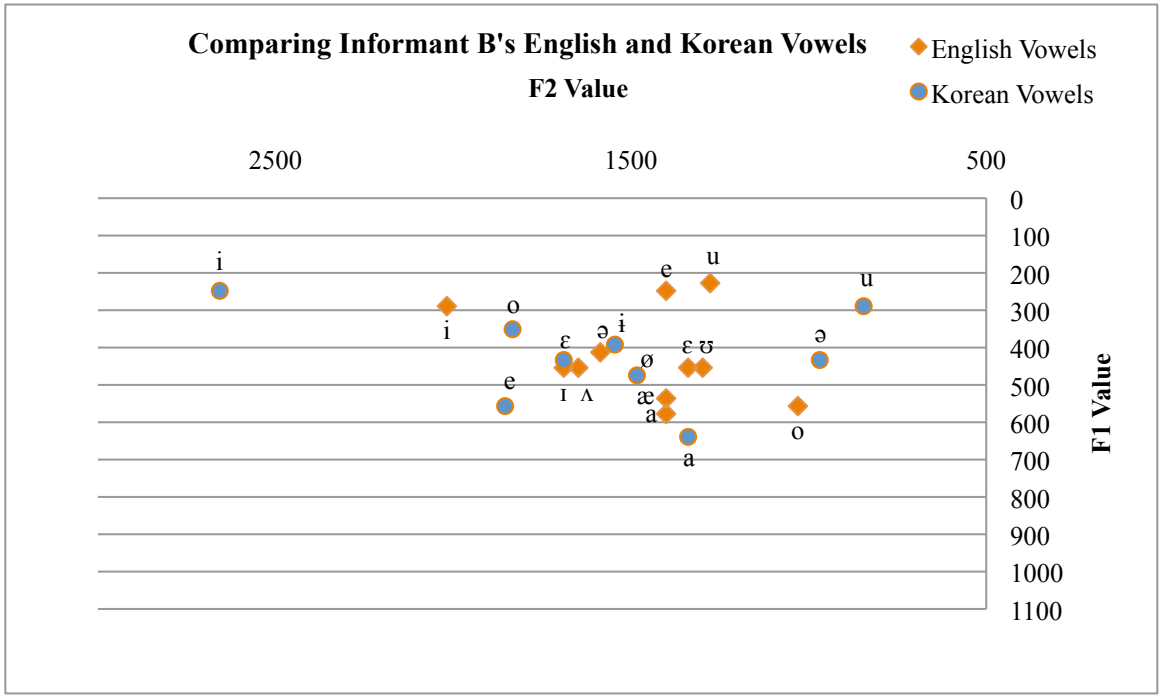

FIGURE 31 Informant B's English and Korean vowels mapped overlaid on top of one another using F1 and F2 measurements for each vowel.

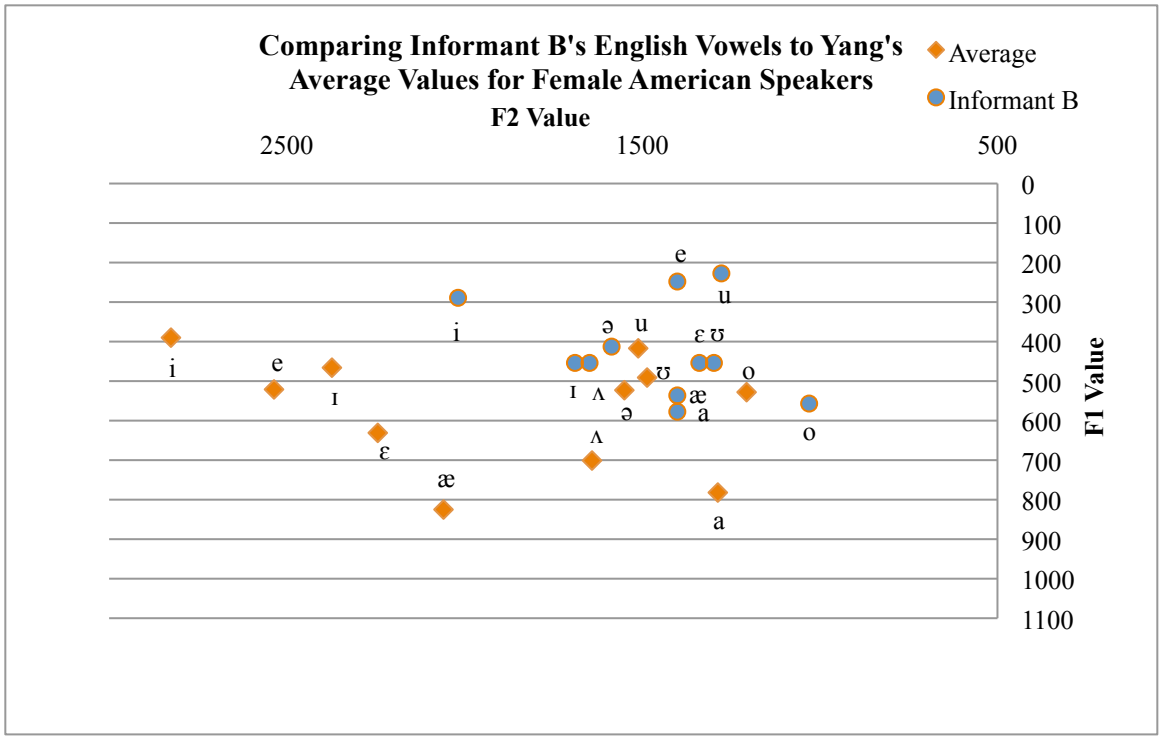

FIGURE 32. Informant B's English vowels plotted using F1 and F2 measurements overlaid on top of the vowel measurements given by Yang's average values for female American speakers.

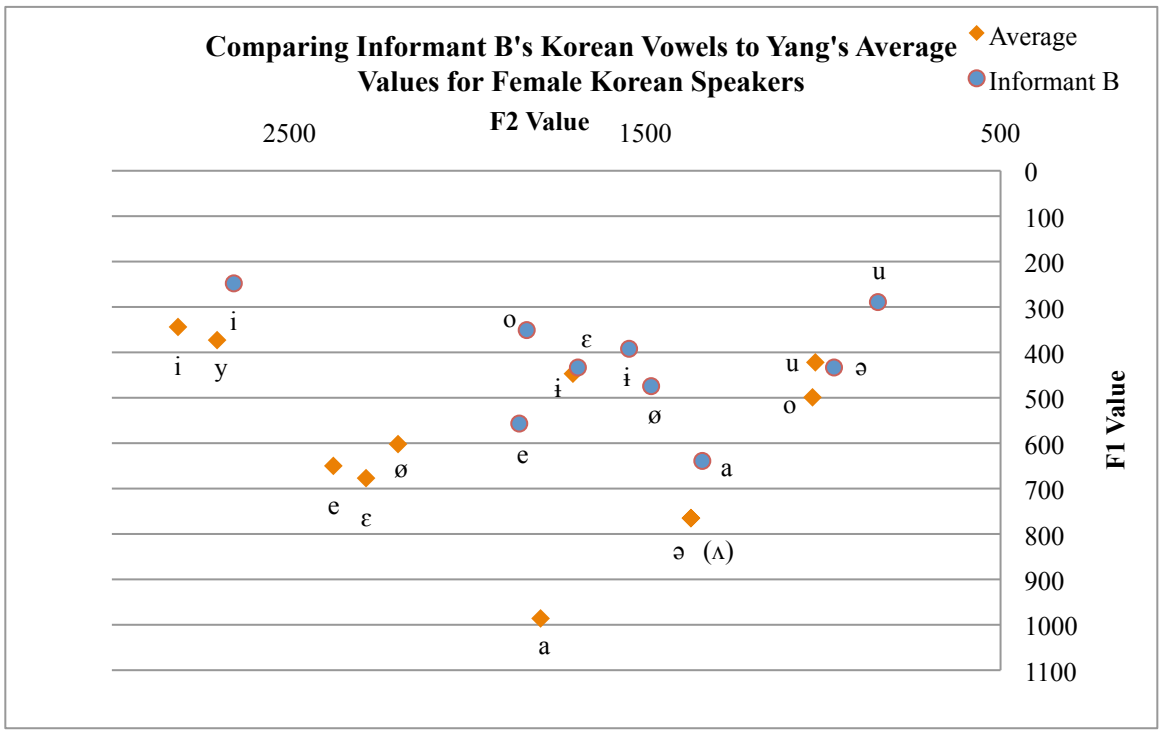

FIGURE 33. Informant B's Korean vowels plotted using F1 and F2 measurements overlaid on top of the vowel measurements given by Yang's average values for female Korean speakers.

INFORMANT C

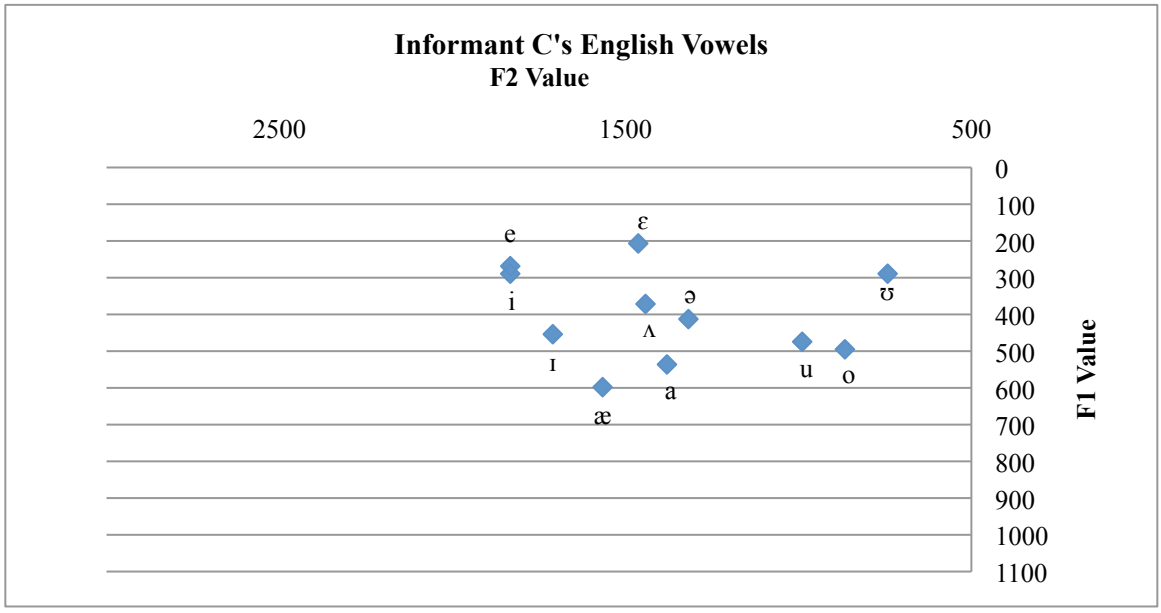

FIGURE 34. Informant C's English vowels plotted using F1 and F2 measurements for each vowel.

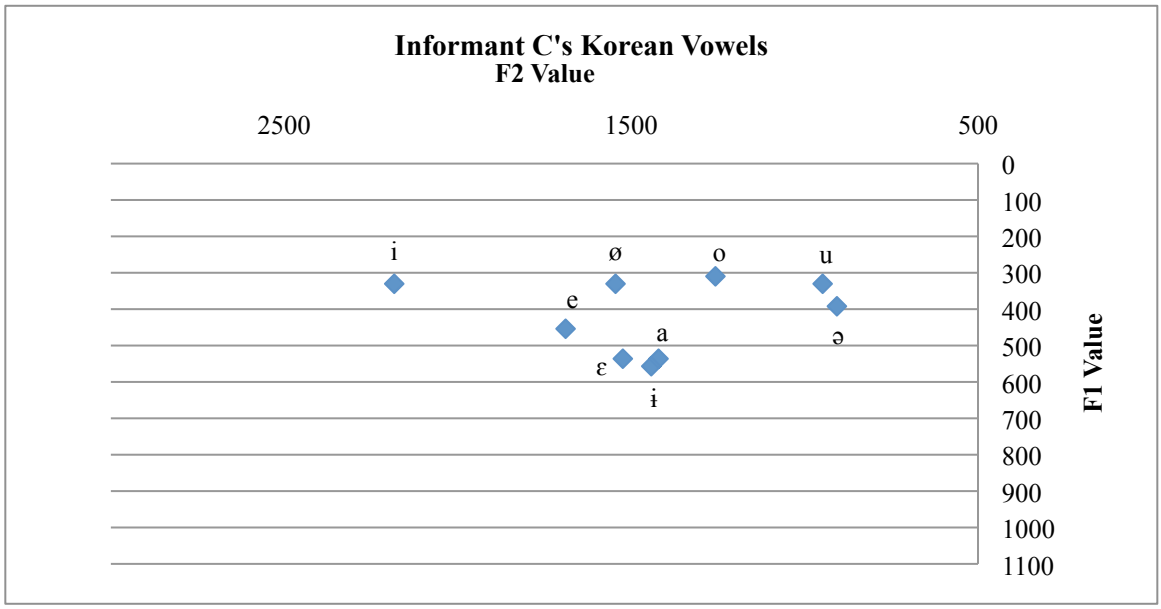

FIGURE 35. Informant C's Korean vowels plotted using F1 and F2 measurements for each vowel.

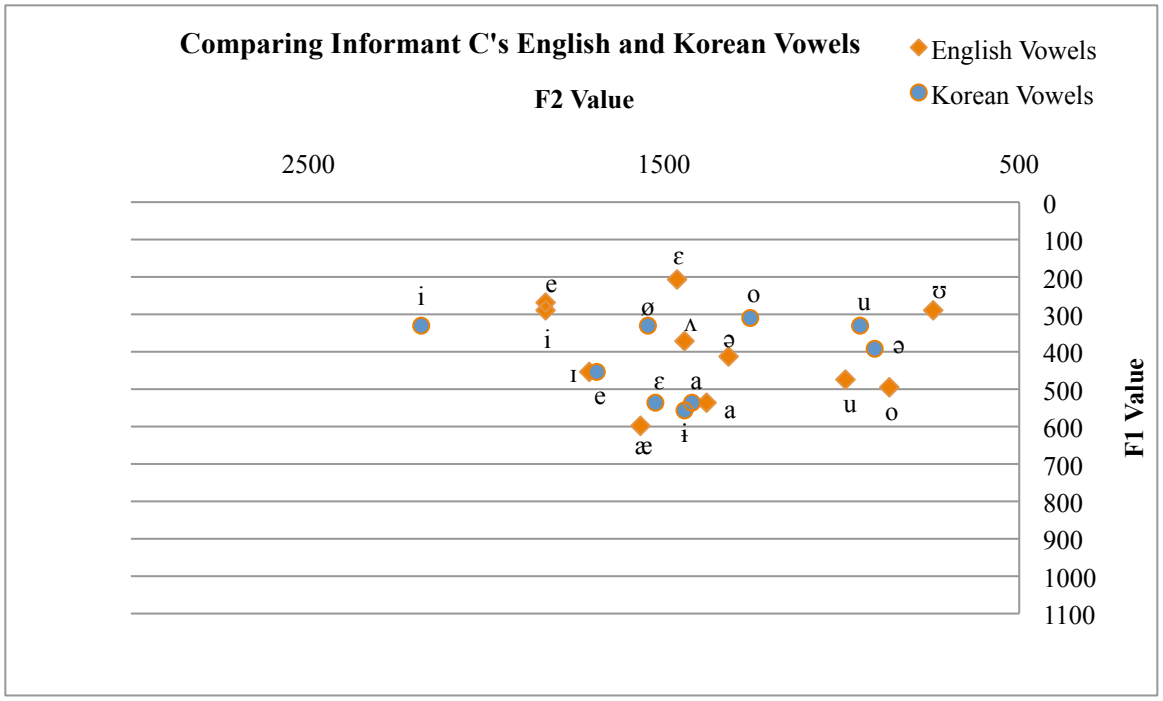

FIGURE 36. Informant C's English and Korean vowels mapped overlaid on top of one another using F1 and F2 measurements for each vowel.

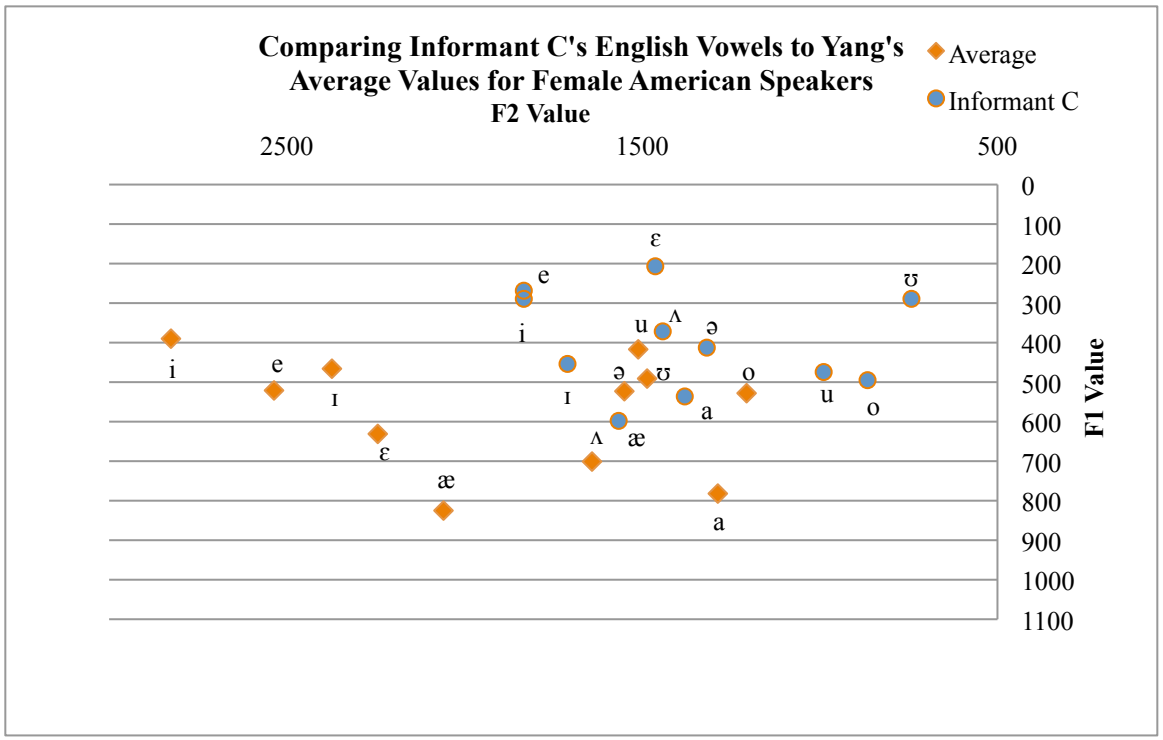

FIGURE 37. Informant C's English vowels plotted using F1 and F2 measurements overlaid on top of the vowel measurements given by Yang's average values for female American speakers.

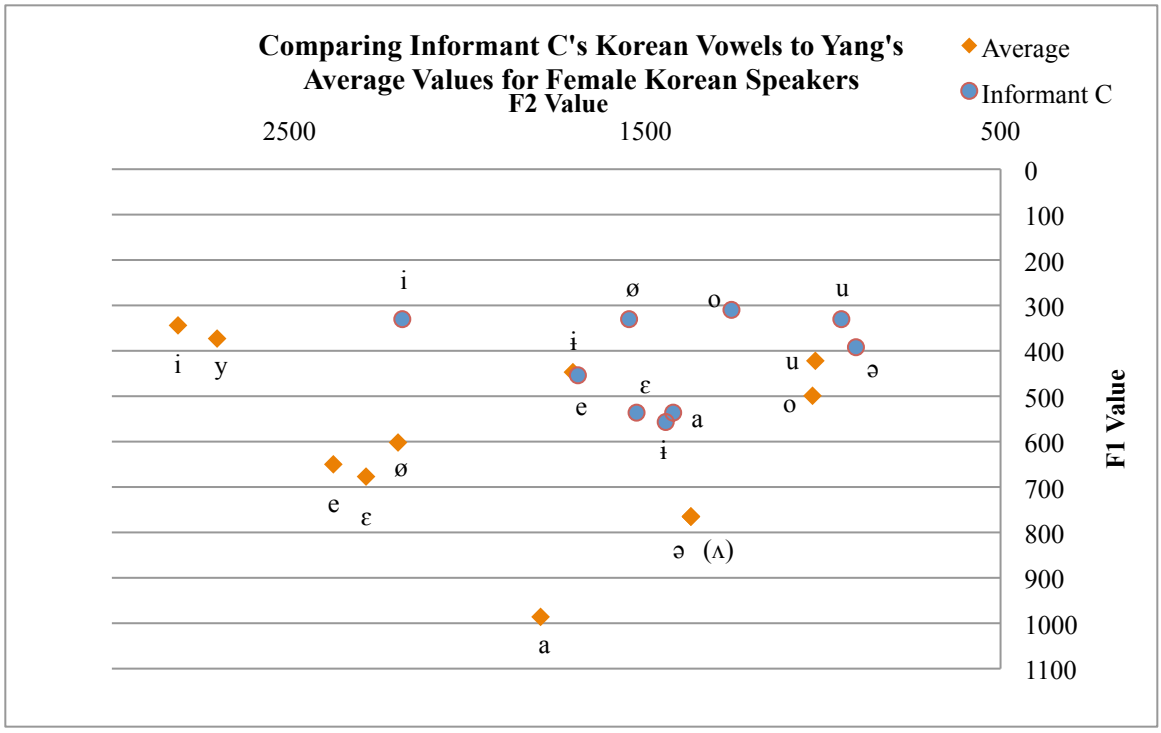

FIGURE 38. Informant C's Korean vowels plotted using F1 and F2 measurements overlaid on top of the vowel measurements given by Yang's average values for female Korean speakers.

INFORMANT D

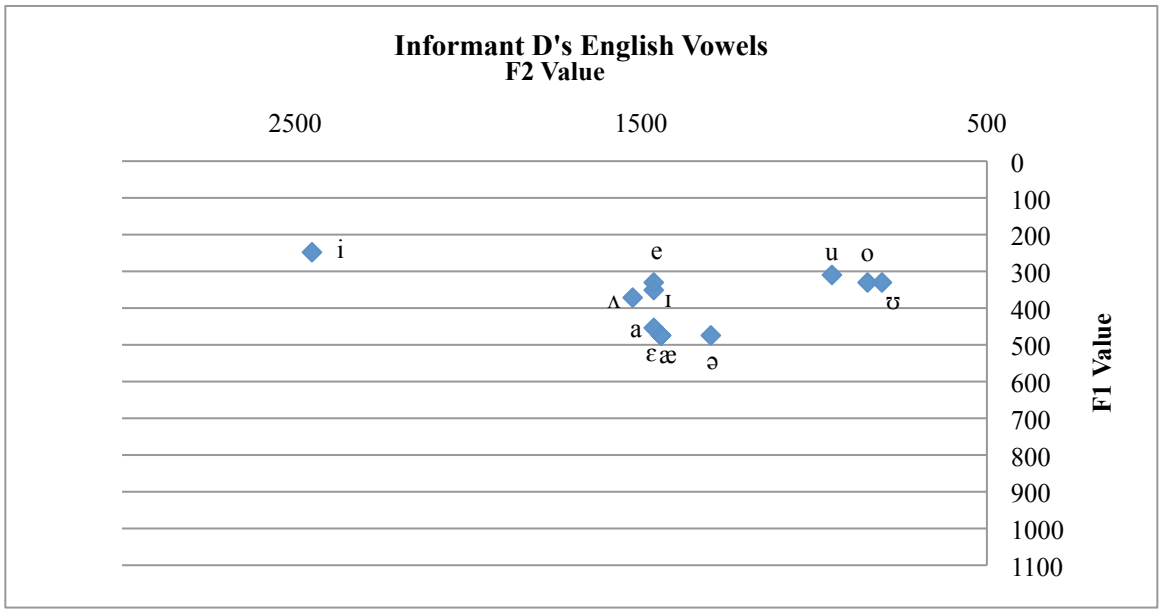

FIGURE 39. Informant D's English vowels plotted using F1 and F2 measurements for each vowel.

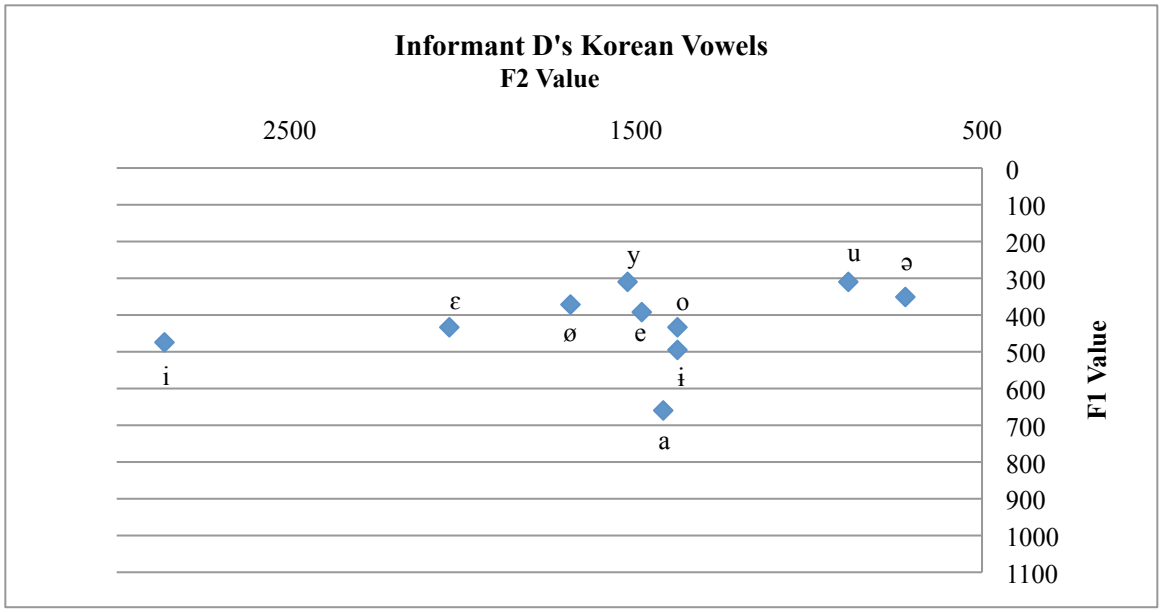

FIGURE 40. Informant D's Korean vowels plotted using F1 and F2 measurements for each vowel.

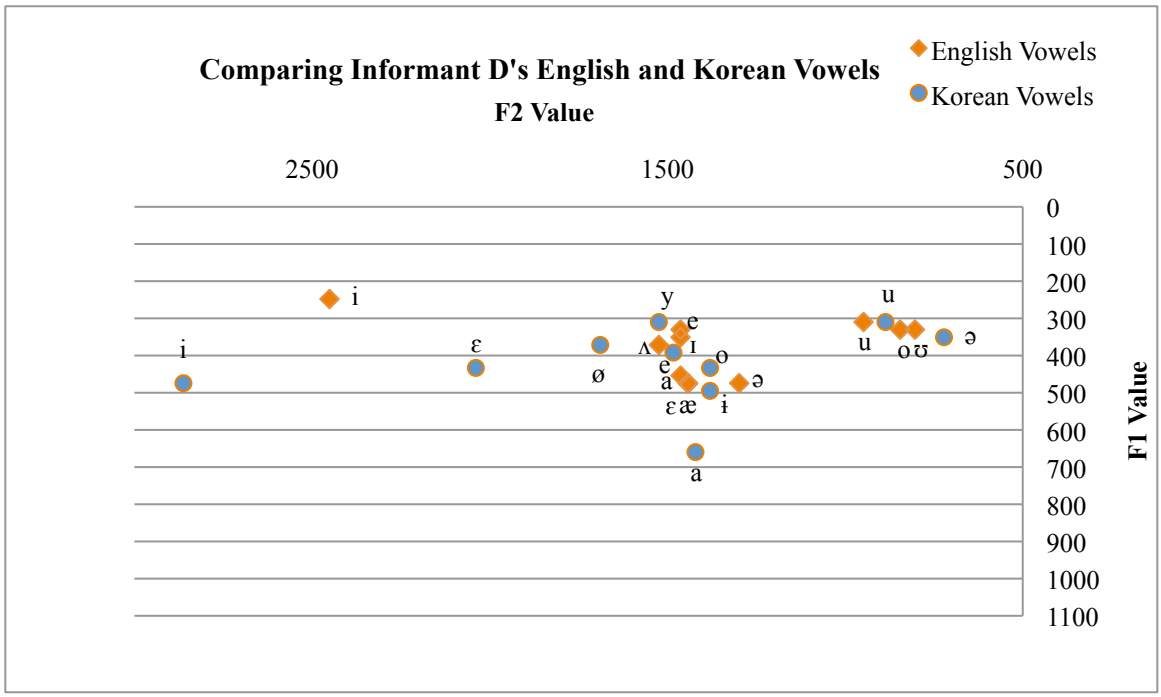

FIGURE 41. Informant D's English and Korean vowels mapped overlaid on top of one another using F1 and F2 measurements for each vowel.

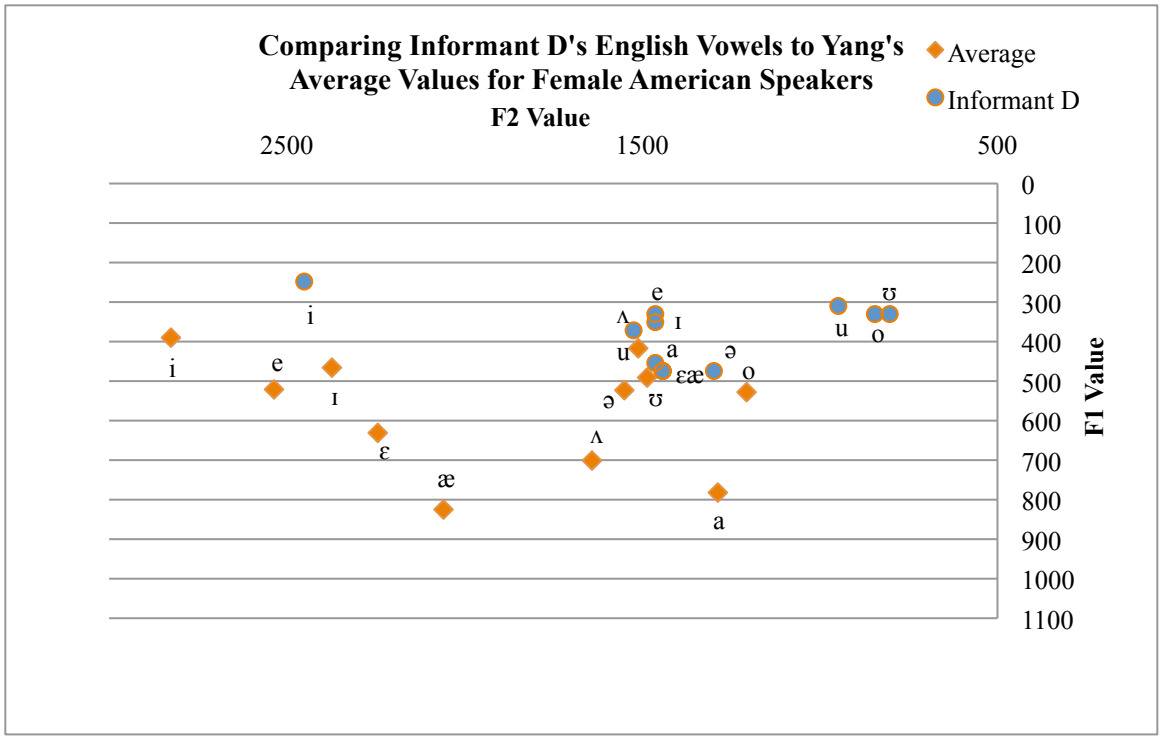

FIGURE 42. Informant C's English vowels plotted using F1 and F2 measurements overlaid on top of the vowel measurements given by Yang's average values for female American speakers.

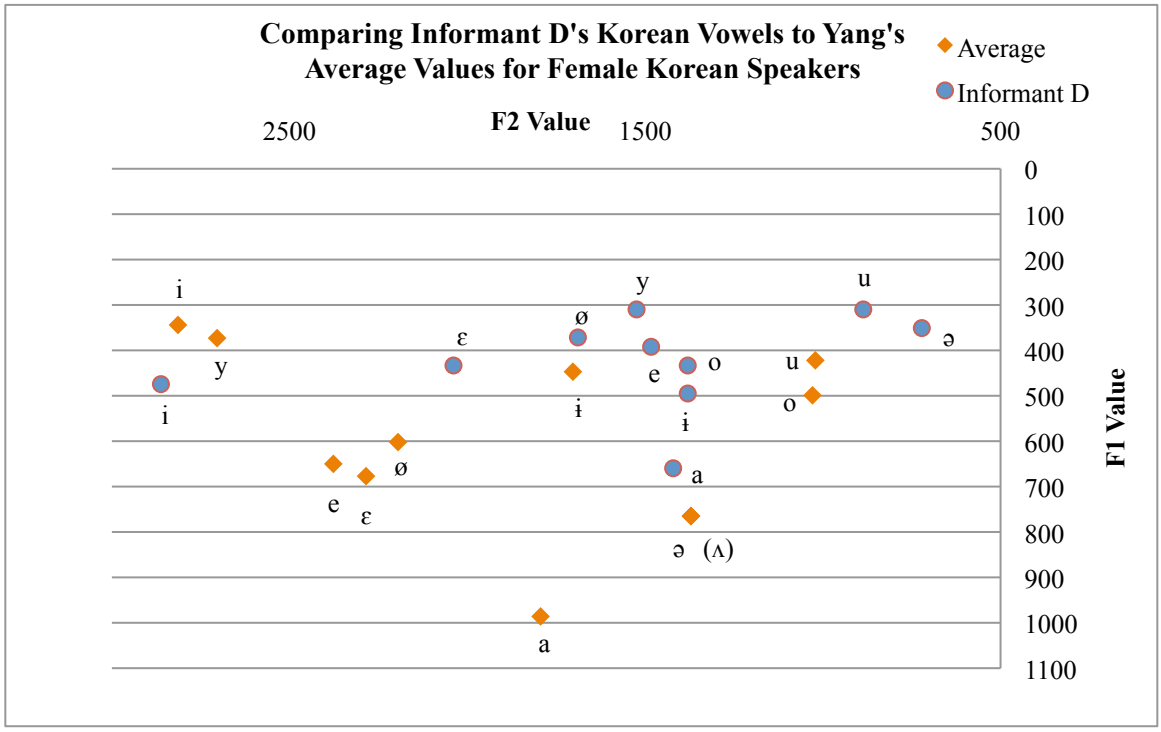

FIGURE 43. Informant D's Korean vowels plotted using F1 and F2 measurements overlaid on top of the vowel measurements given by Yang's average values for female Korean speakers.

INFORMANT E

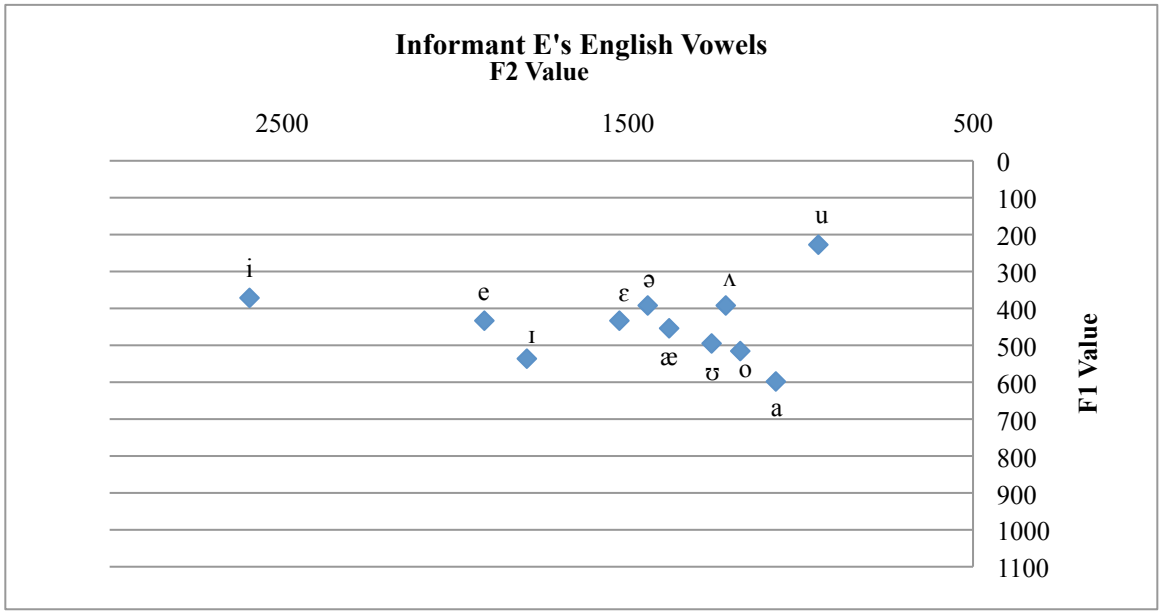

FIGURE 44. Informant E's English vowels plotted using F1 and F2 measurements for each vowel.

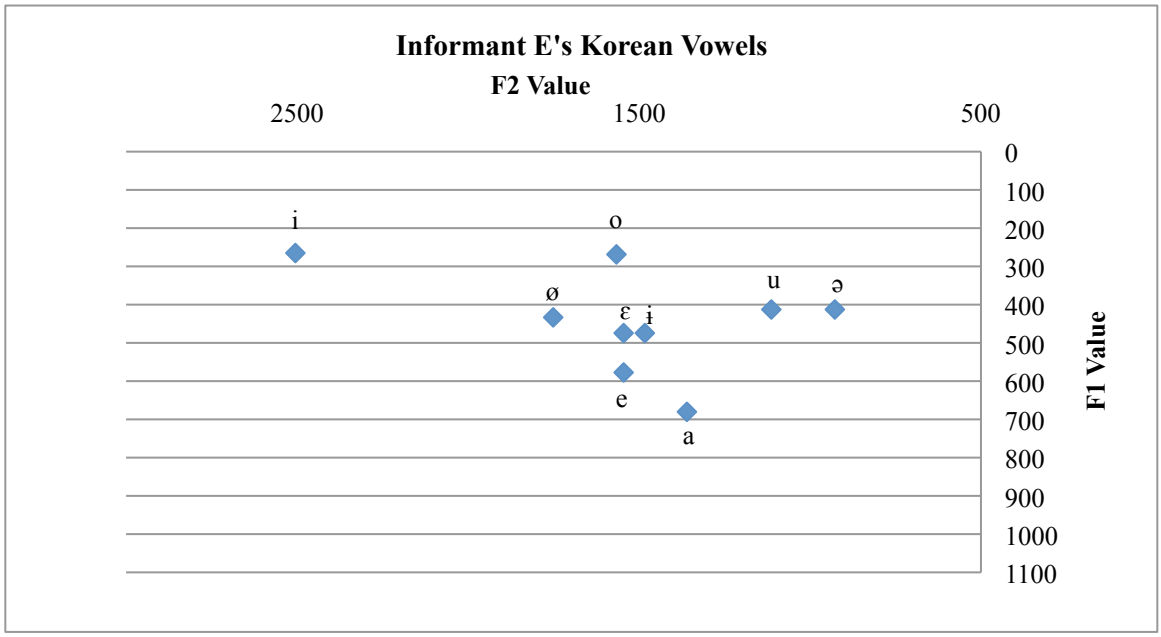

FIGURE 45. Informant E's Korean vowels plotted using F1 and F2 measurements for each vowel.

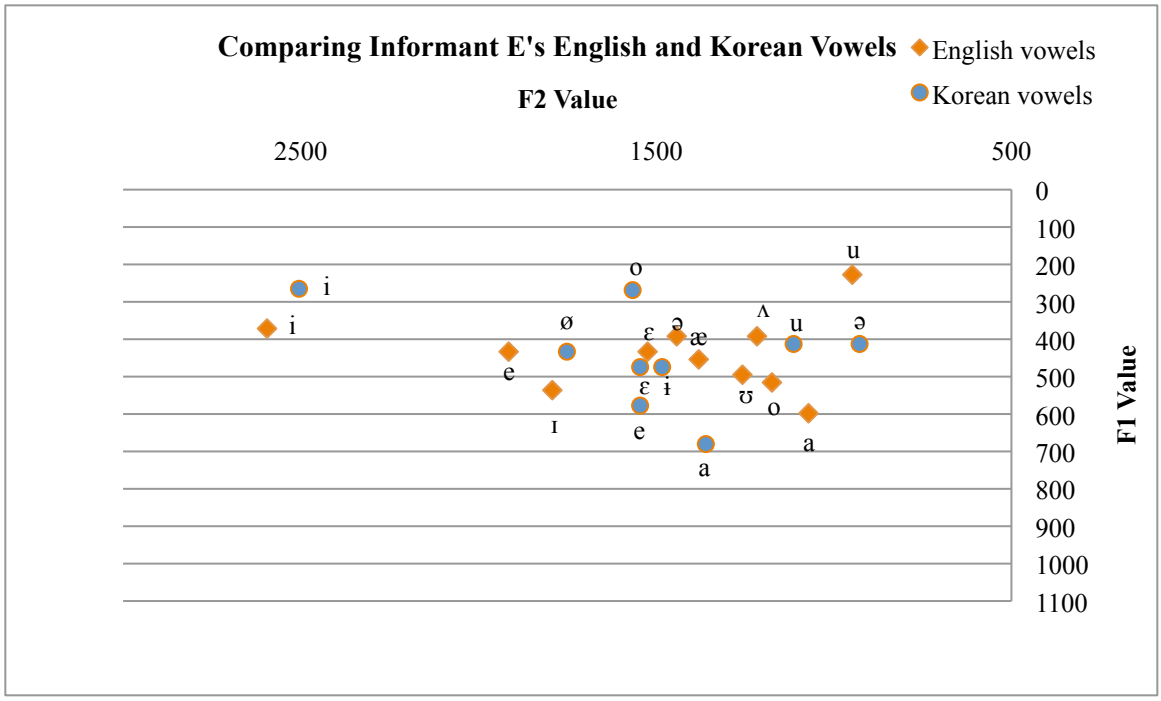

FIGURE 46. Informant D's English and Korean vowels mapped overlaid on top of one another using F1 and F2 measurements for each vowel.

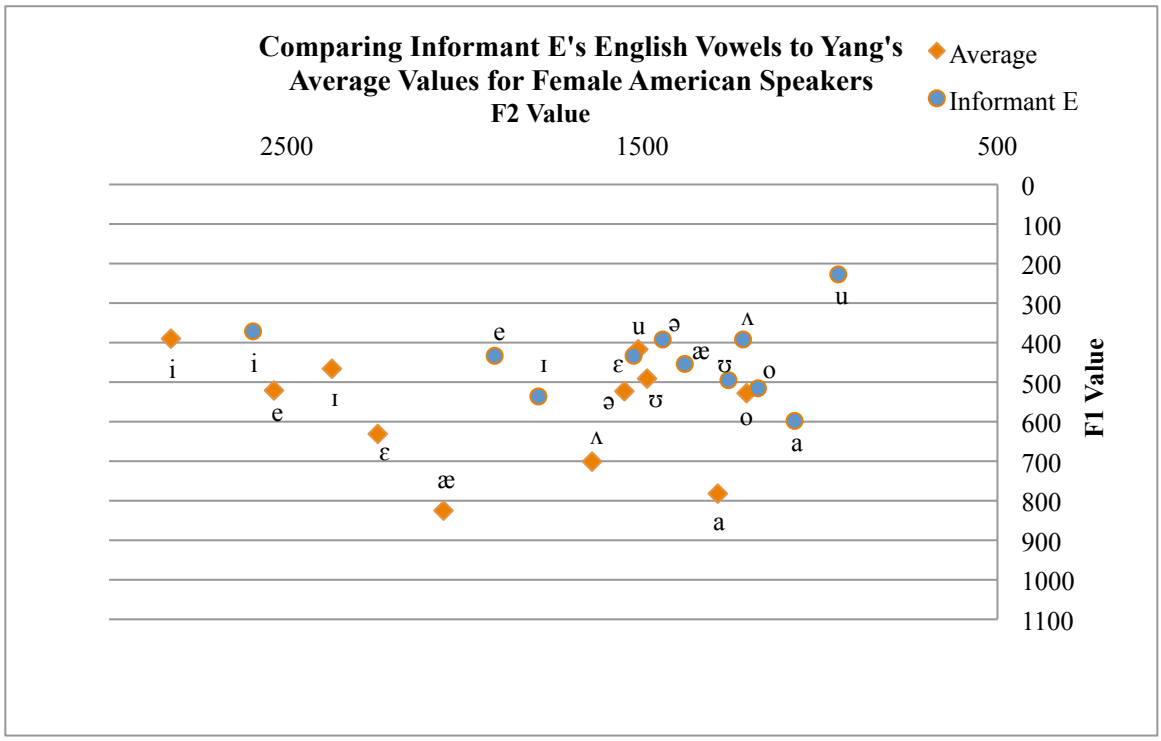

FIGURE 47. Informant E's English vowels plotted using F1 and F2 measurements overlaid on top of the vowel measurements given by Yang's average values for female American speakers.

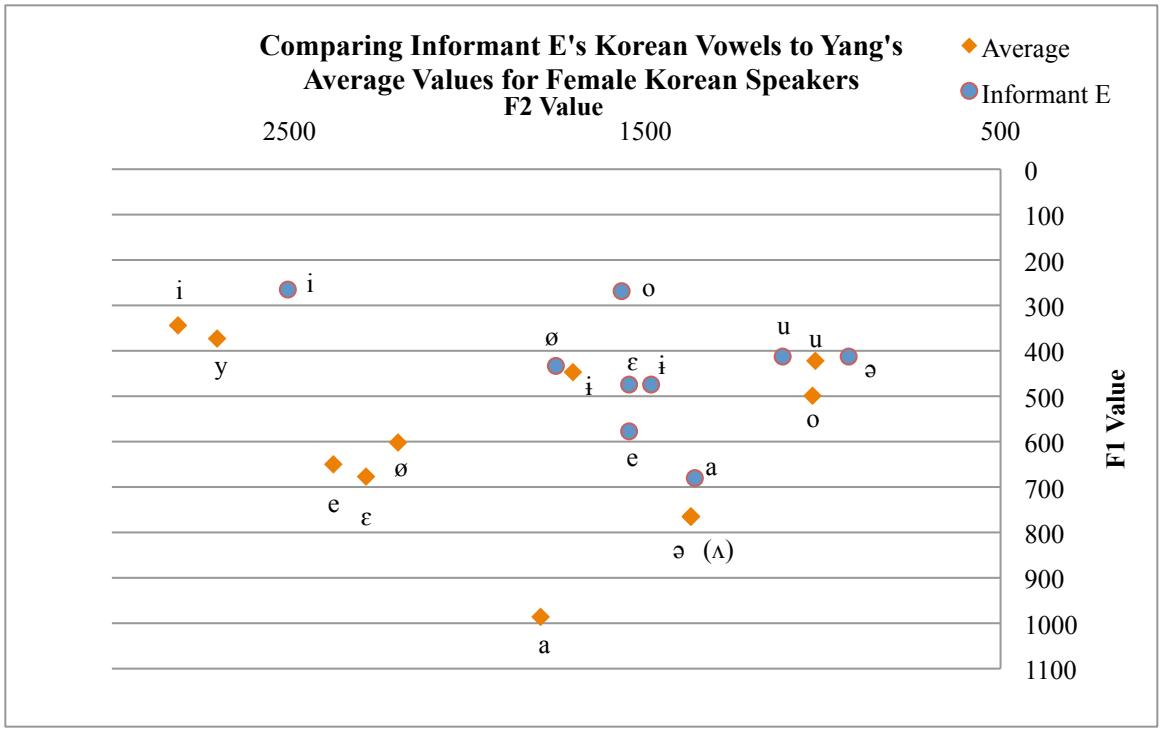

FIGURE 48. Informant E's Korean vowels plotted using F1 and F2 measurements overlaid on top of the vowel measurements given by Yang's average values for female Korean speakers.

INFORMANT F

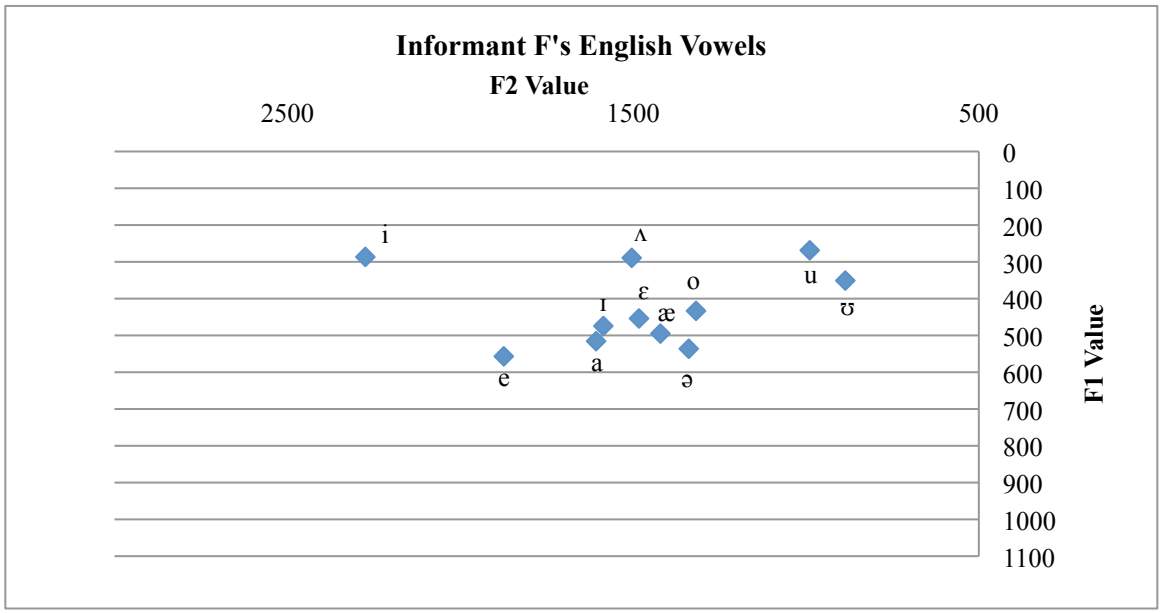

FIGURE 49. Informant F's English vowels plotted using F1 and F2 measurements for each vowel.

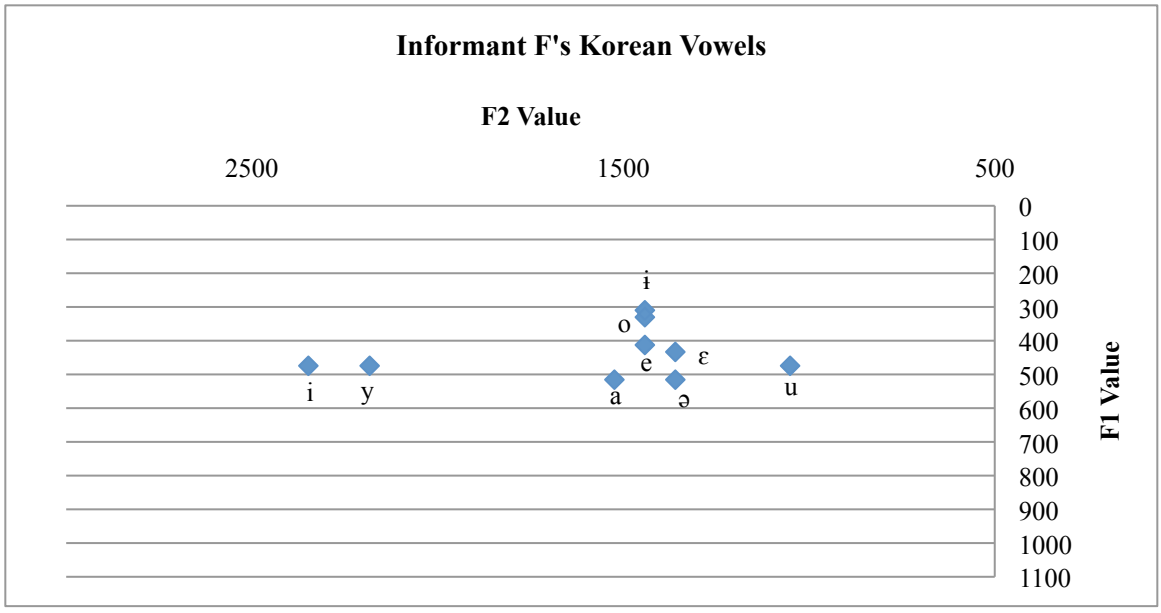

FIGURE 50. Informant F's Korean vowels plotted using F1 and F2 measurements for each vowel.

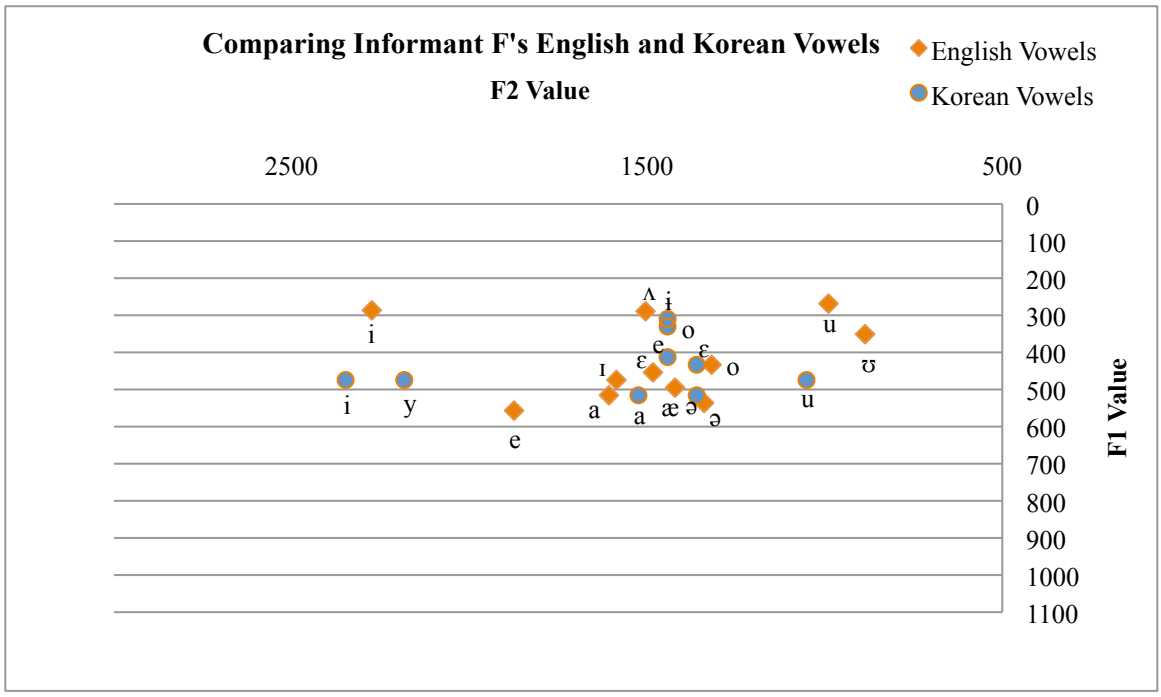

FIGURE 51. Informant F's English and Korean vowels mapped overlaid on top of one another using F1 and F2 measurements for each vowel.

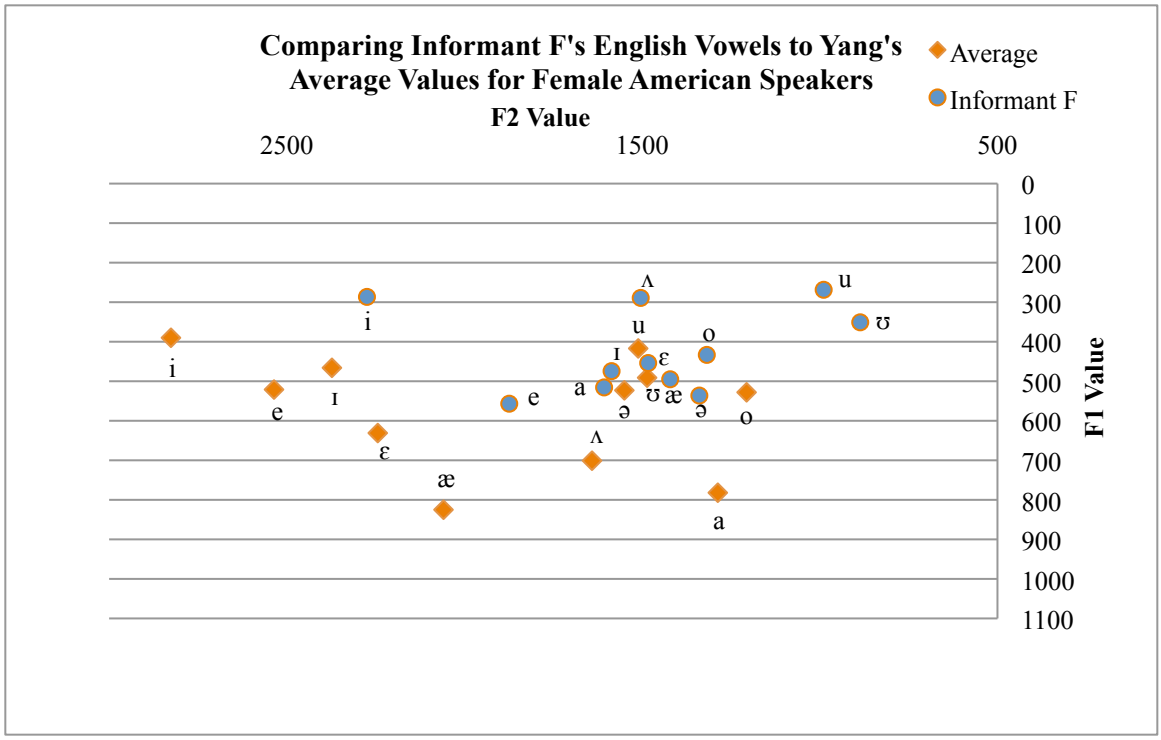

FIGURE 52. Informant F's English vowels plotted using F1 and F2 measurements overlaid on top of the vowel measurements given by Yang's average values for female American speakers.

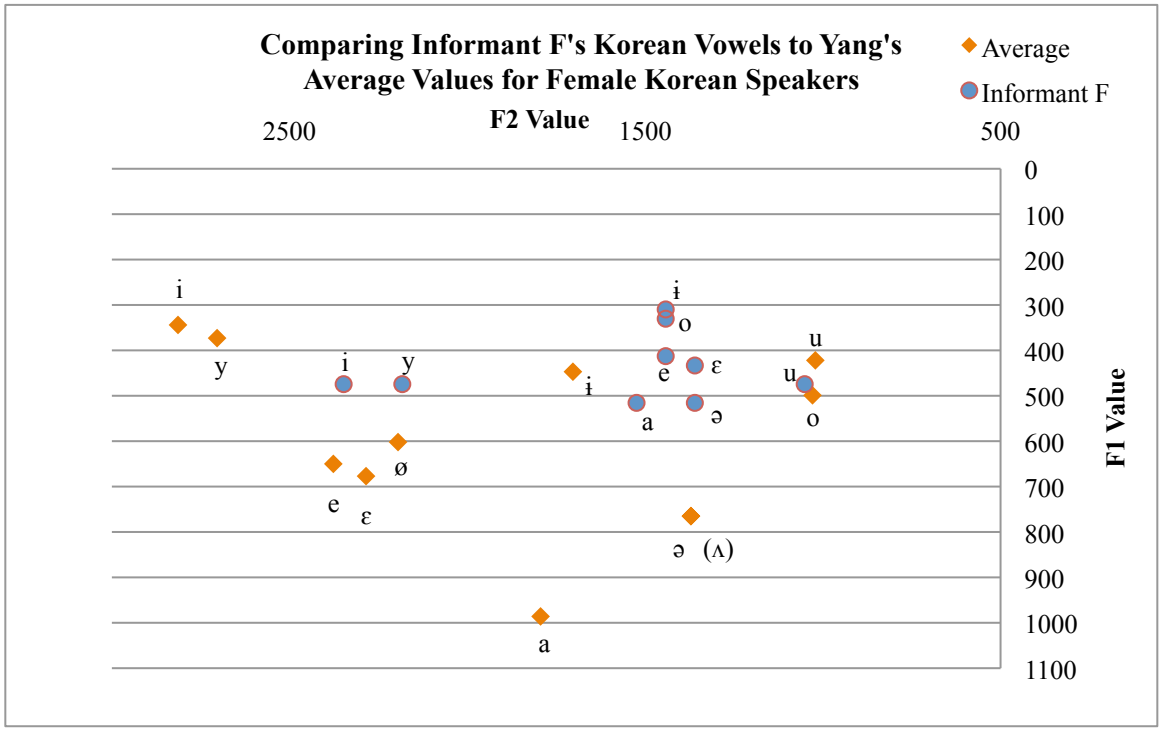

FIGURE 53. Informant F's Korean vowels plotted using F1 and F2 measurements overlaid on top of the vowel measurements given by Yang's average values for female Korean speakers.

INFORMANT G

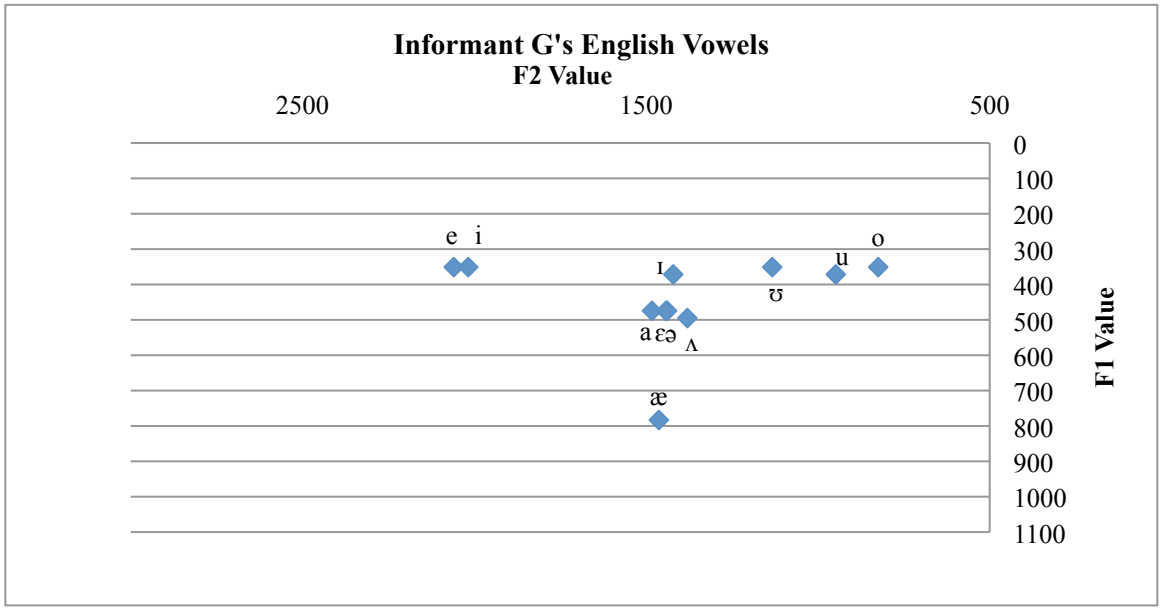

FIGURE 54. Informant G's English vowels plotted using F1 and F2 measurements for each vowel.

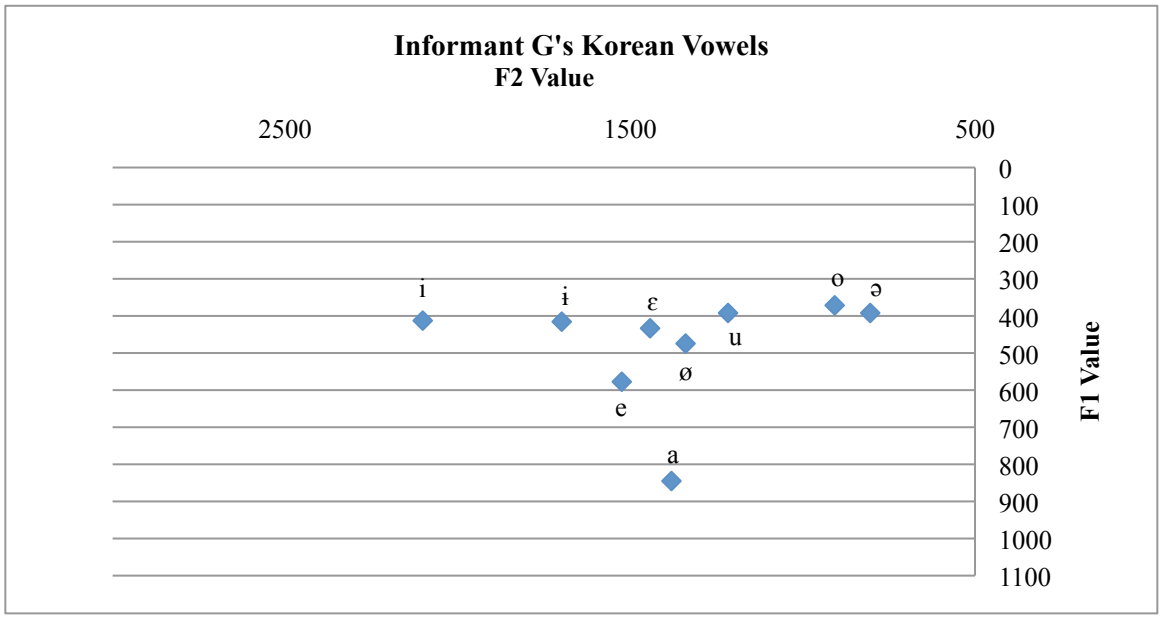

FIGURE 55. Informant G's Korean vowels plotted using F1 and F2 measurements for each vowel.

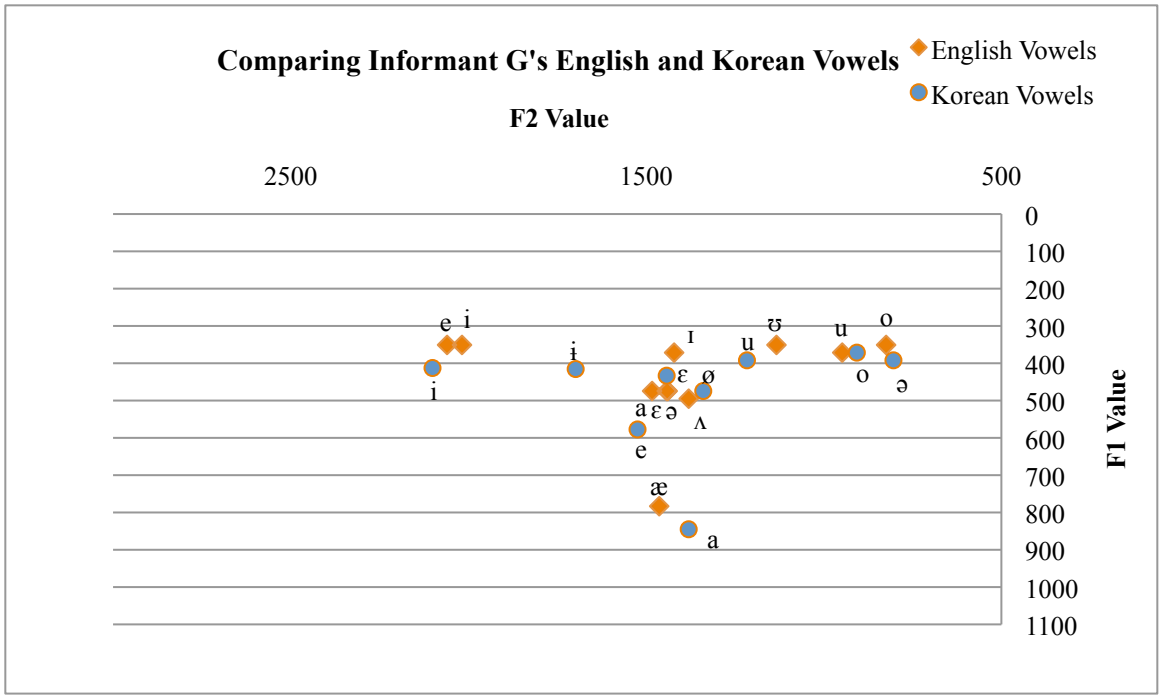

FIGURE 56. Informant G's English and Korean vowels mapped overlaid on top of one another using F1 and F2 measurements for each vowel.

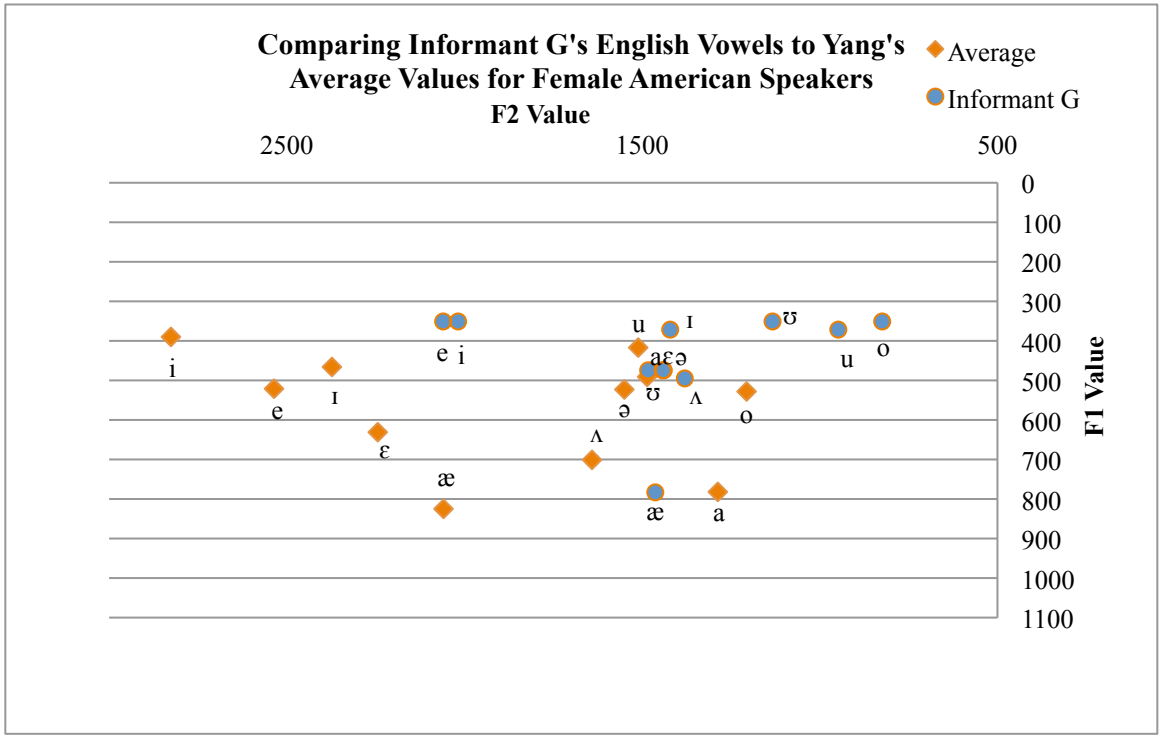

FIGURE 57. Informant G's English vowels plotted using F1 and F2 measurements overlaid on top of the vowel measurements given by Yang's average values for female American speakers.

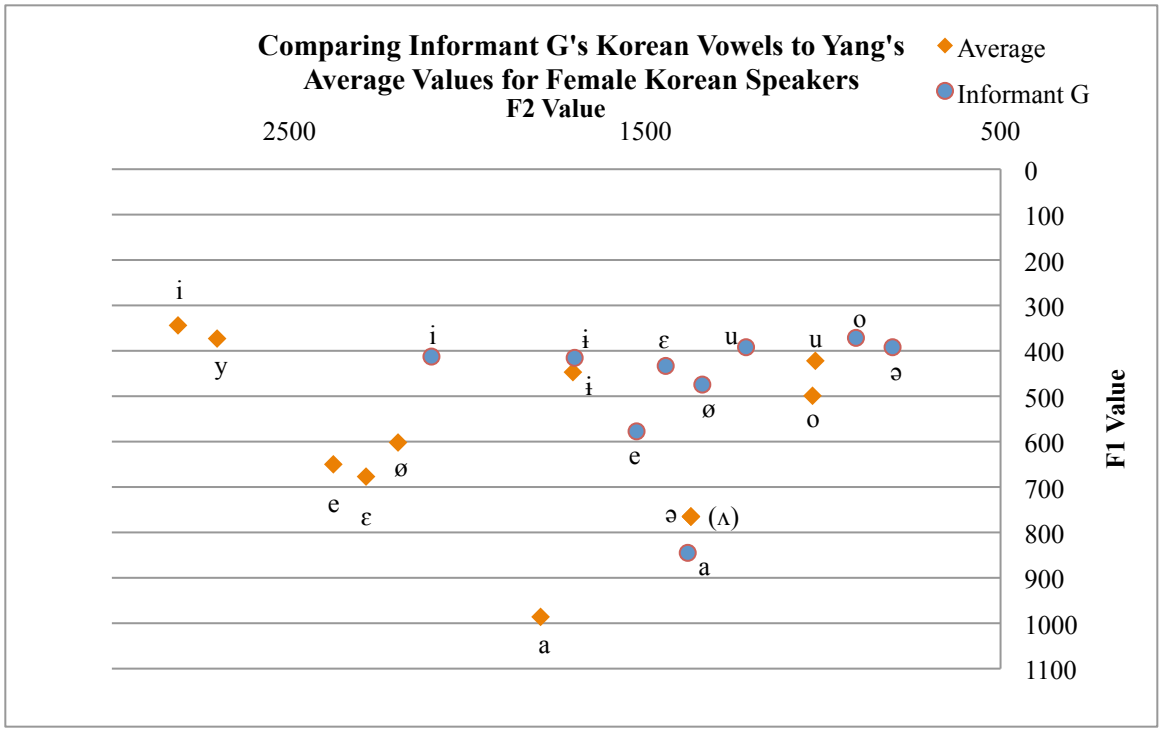

FIGURE 58. Informant G's Korean vowels plotted using F1 and F2 measurements overlaid on top of the vowel measurements given by Yang's average values for female Korean speakers.

INFORMANT H

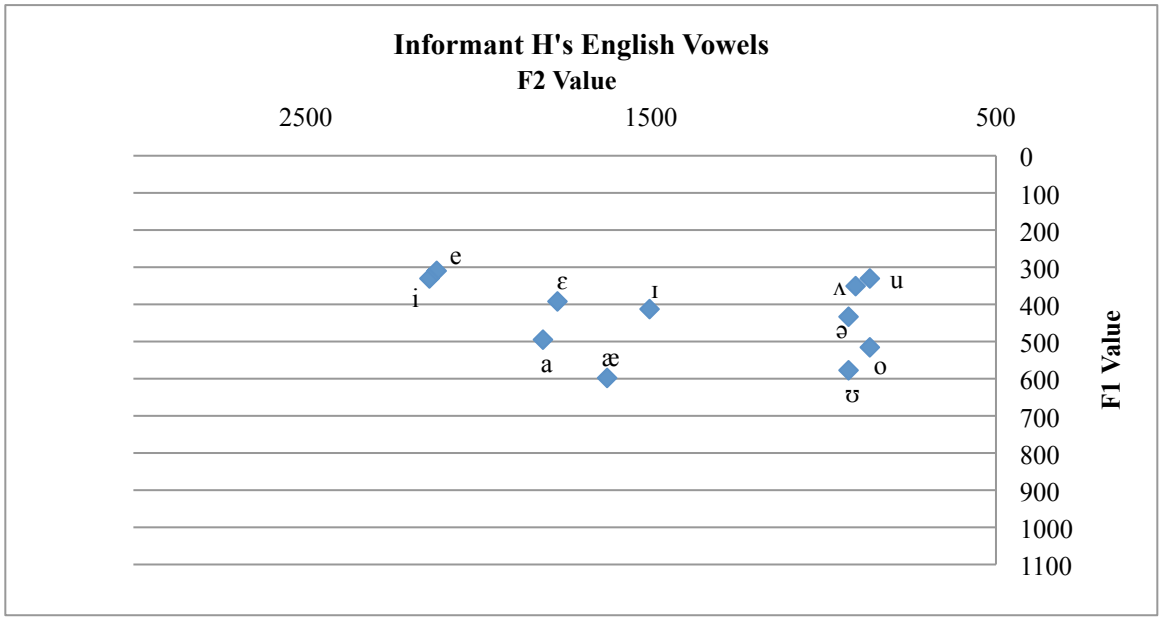

FIGURE 59. Informant H's English vowels plotted using F1 and F2 measurements for each vowel.

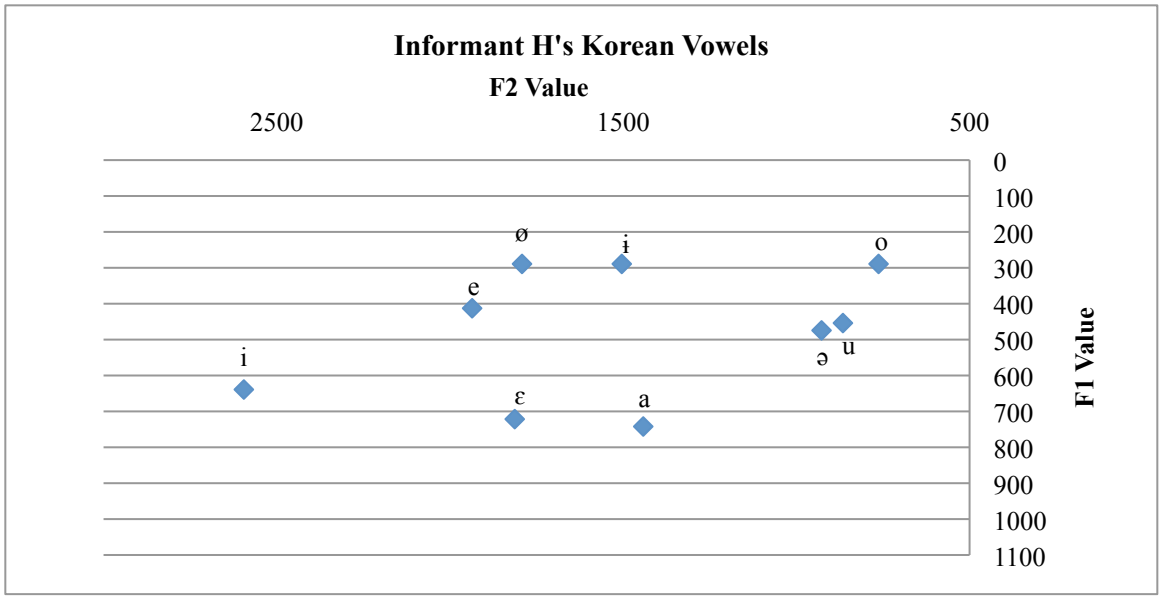

FIGURE 60. Informant H's Korean vowels plotted using F1 and F2 measurements for each vowel.

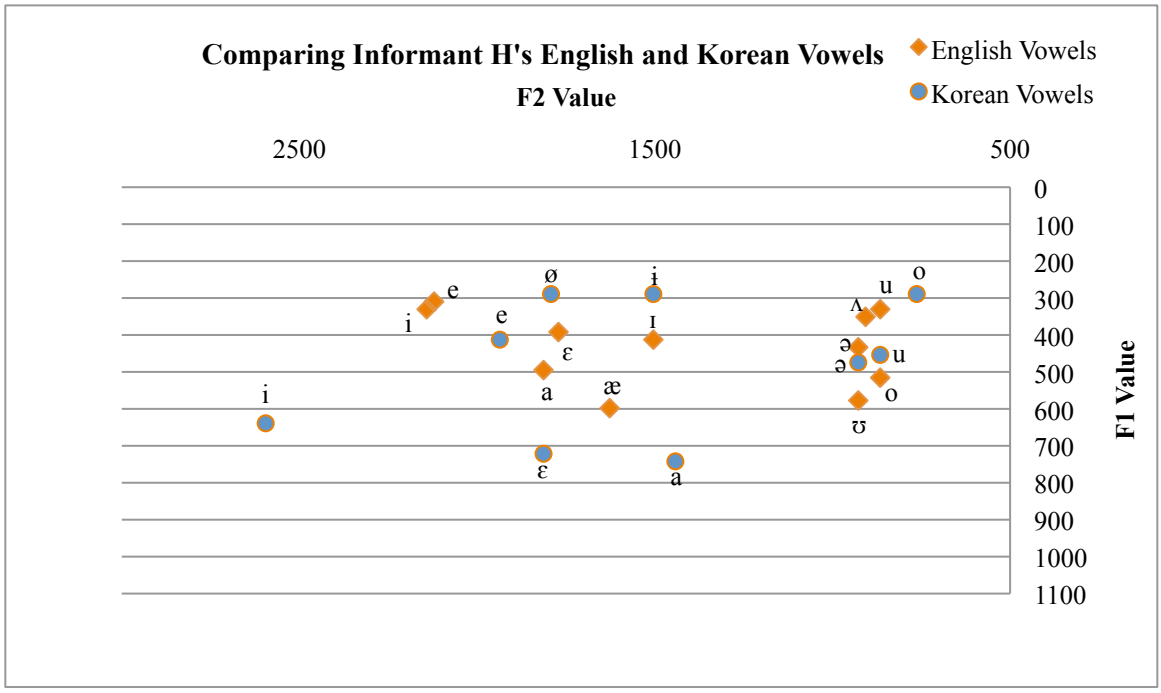

FIGURE 61. Informant H's English and Korean vowels mapped overlaid on top of one another using F1 and F2 measurements for each vowel.

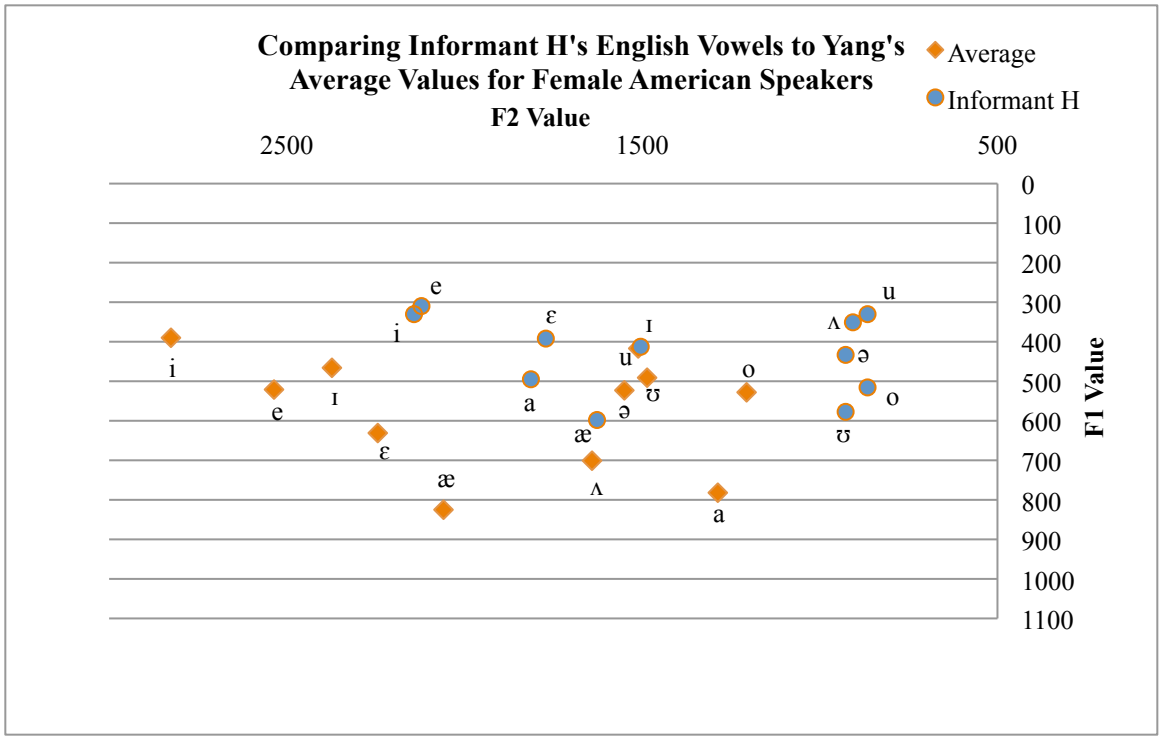

FIGURE 62. Informant H's English vowels plotted using F1 and F2 measurements overlaid on top of the vowel measurements given by Yang's average values for female English speakers.

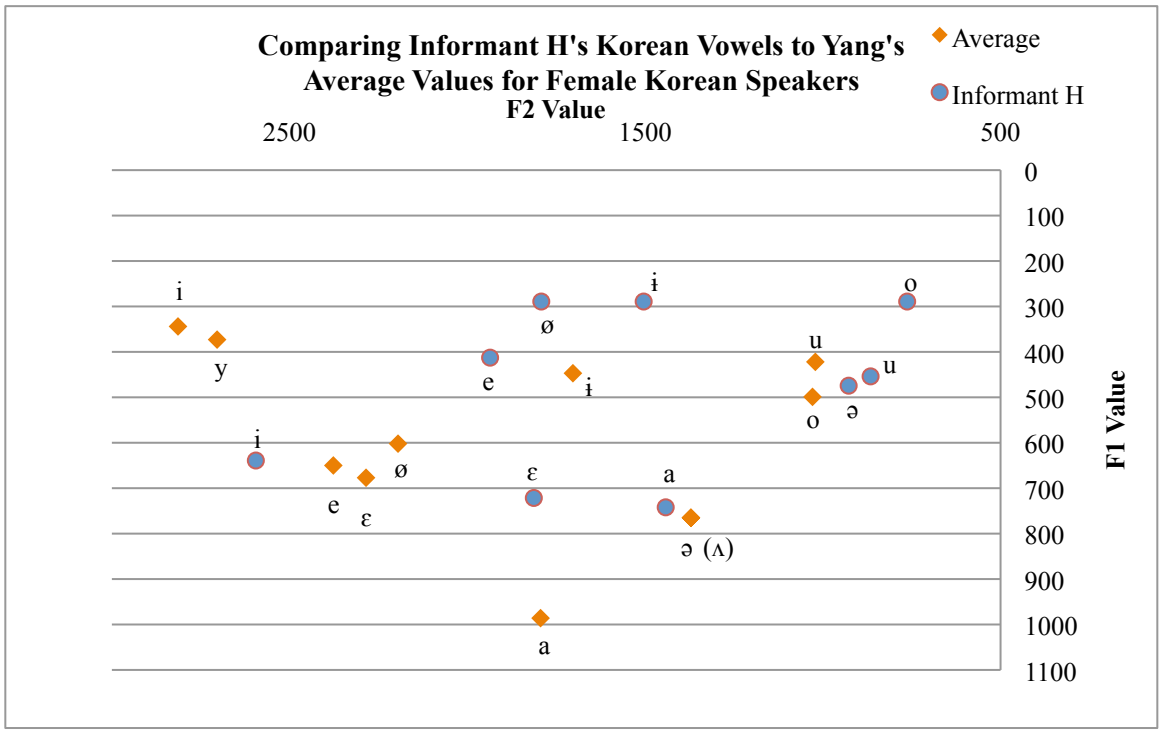

FIGURE 63. Informant H's Korean vowels plotted using F1 and F2 measurements overlaid on top of the vowel measurements given by Yang's average values for female Korean speakers.

INFORMANT I

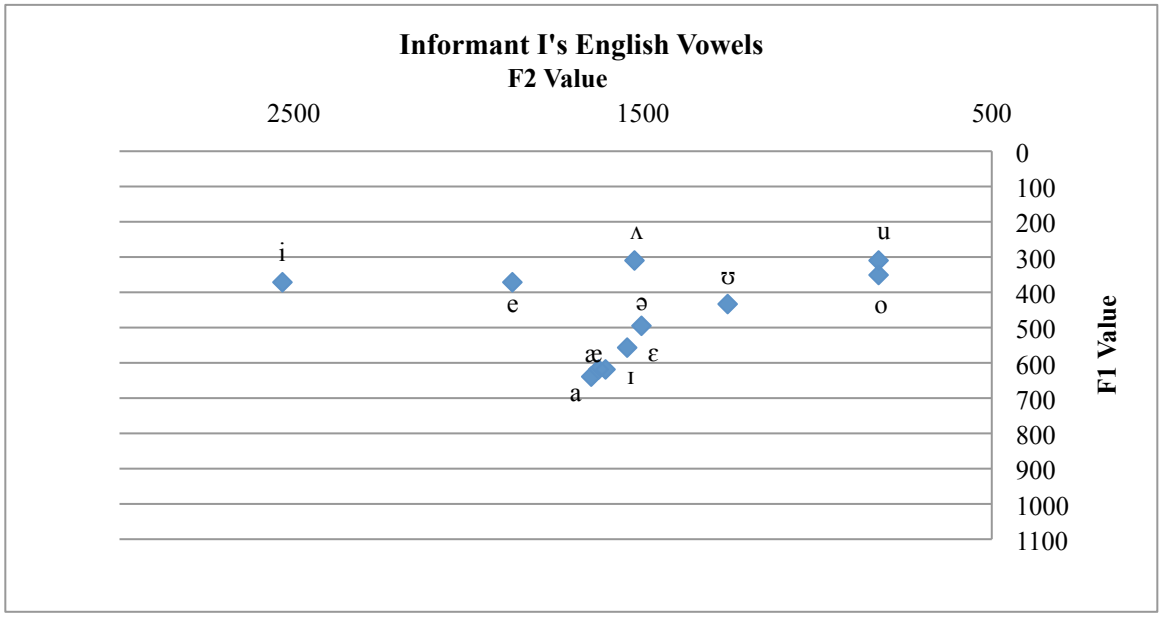

FIGURE 64. Informant I's English vowels plotted using F1 and F2 measurements for each vowel.

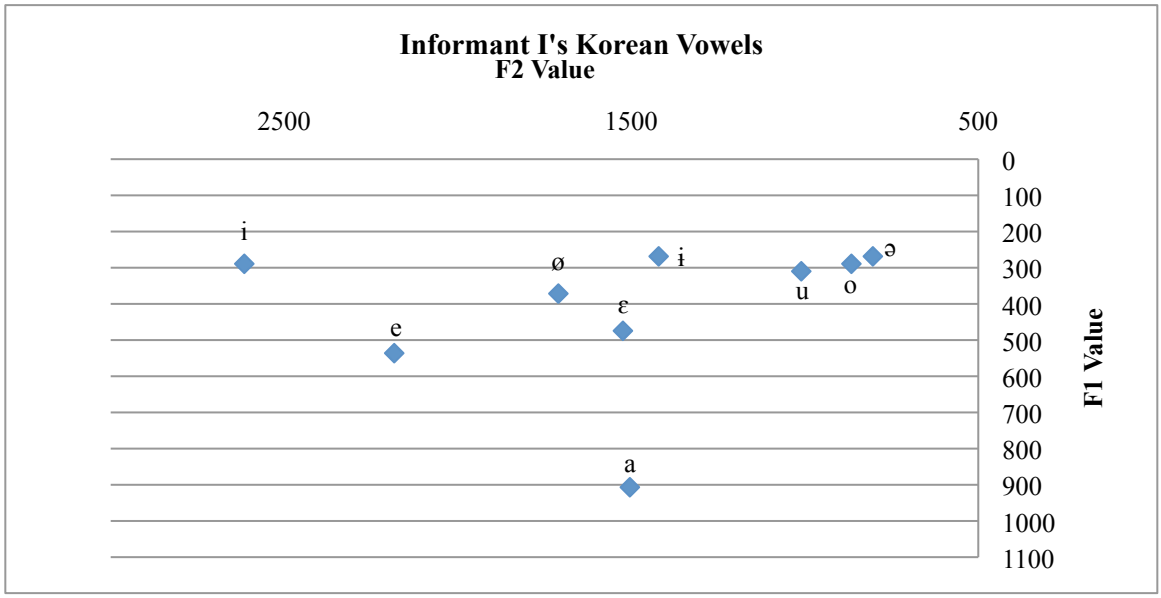

FIGURE 65. Informant I's English vowels plotted using F1 and F2 measurements for each vowel.

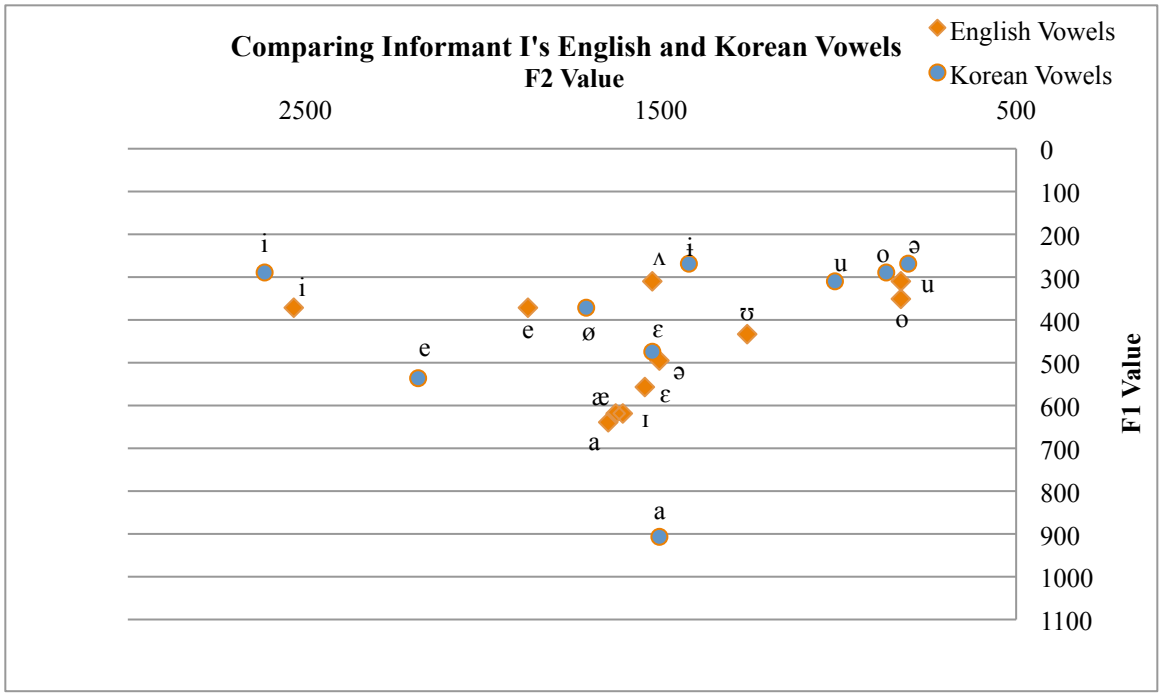

FIGURE 66. Informant I's English and Korean vowels mapped overlaid on top of one another using F1 and F2 measurements for each vowel.

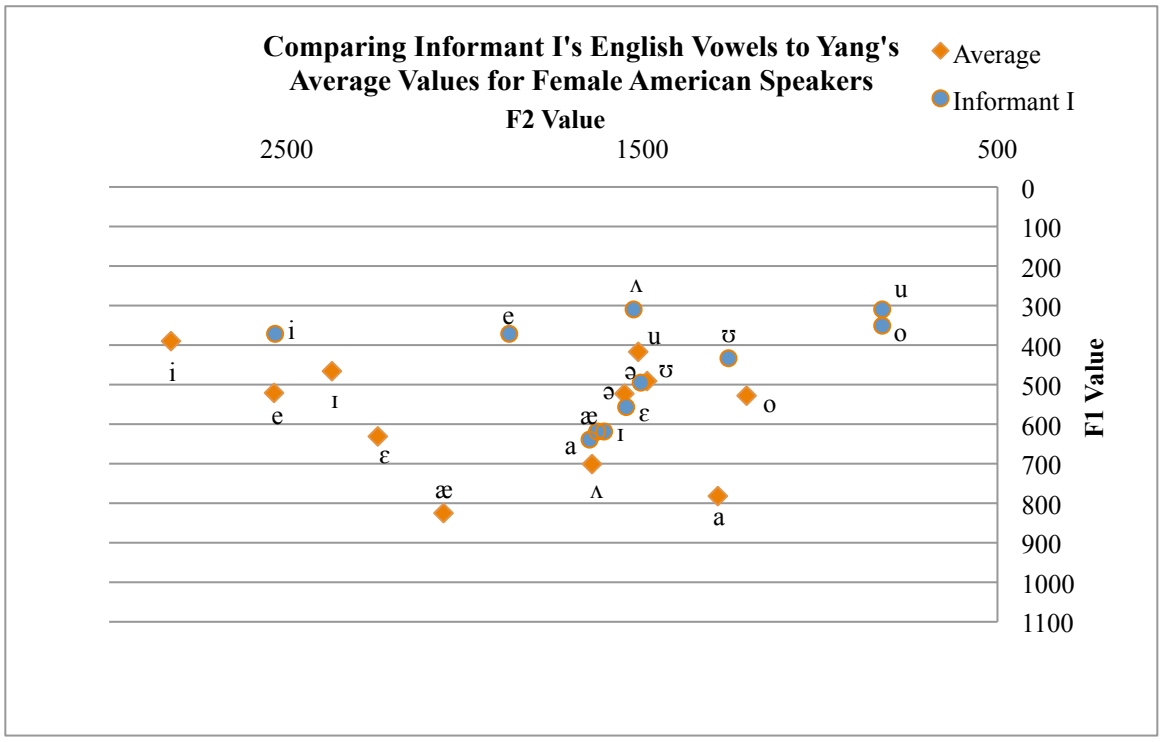

FIGURE 67. Informant I's English vowels plotted using F1 and F2 measurements overlaid on top of the vowel measurements given by Yang's average values for female American speakers.

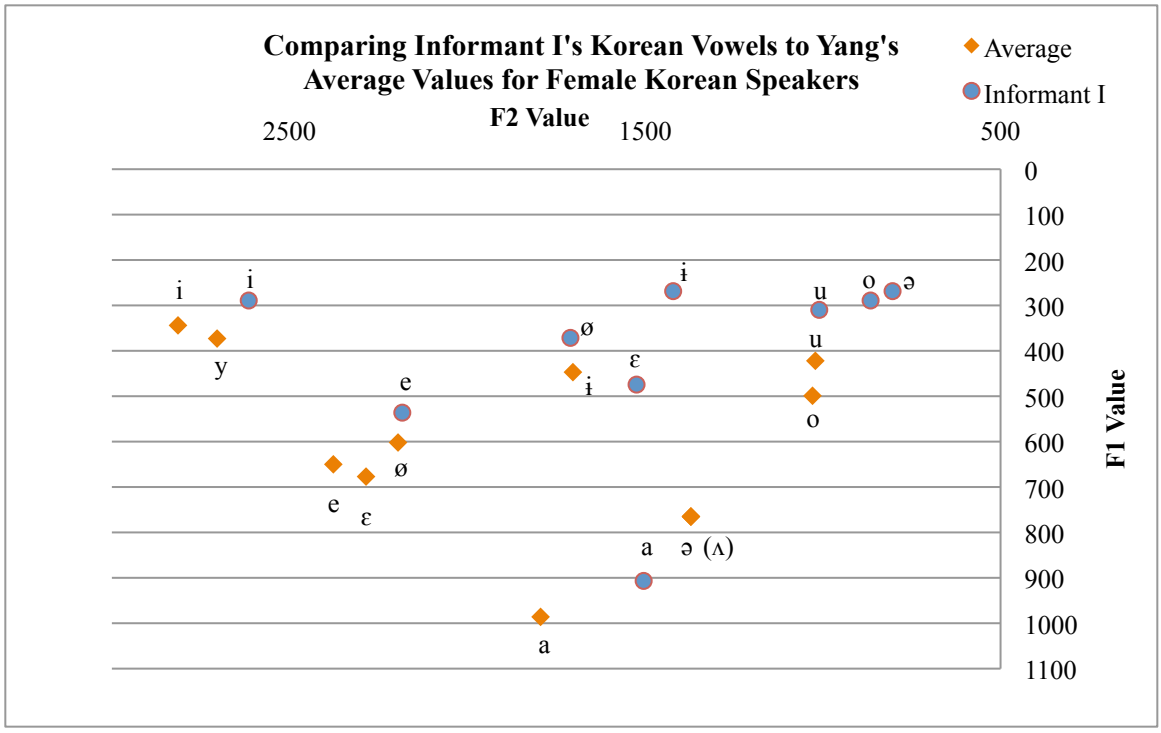

FIGURE 68. Informant I's Korean vowels plotted using F1 and F2 measurements overlaid on top of the vowel measurements given by Yang's average values for female Korean speakers.

INFORMANT J

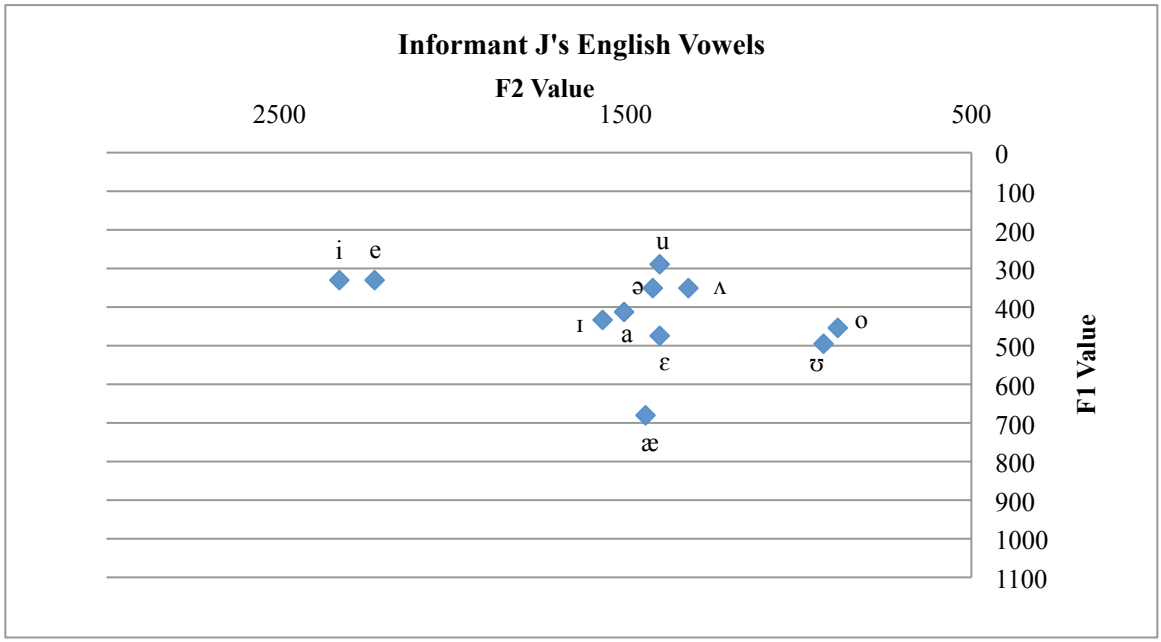

FIGURE 69. Informant J's English vowels plotted using F1 and F2 measurements for each vowel.

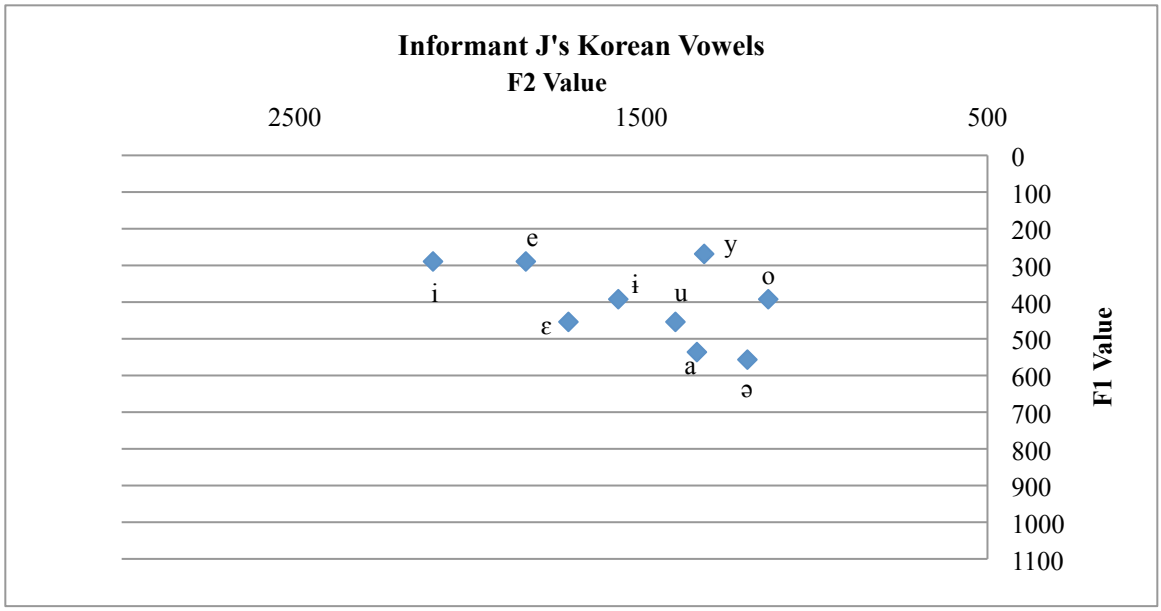

FIGURE 70. Informant J's Korean vowels plotted using F1 and F2 measurements for each vowel.

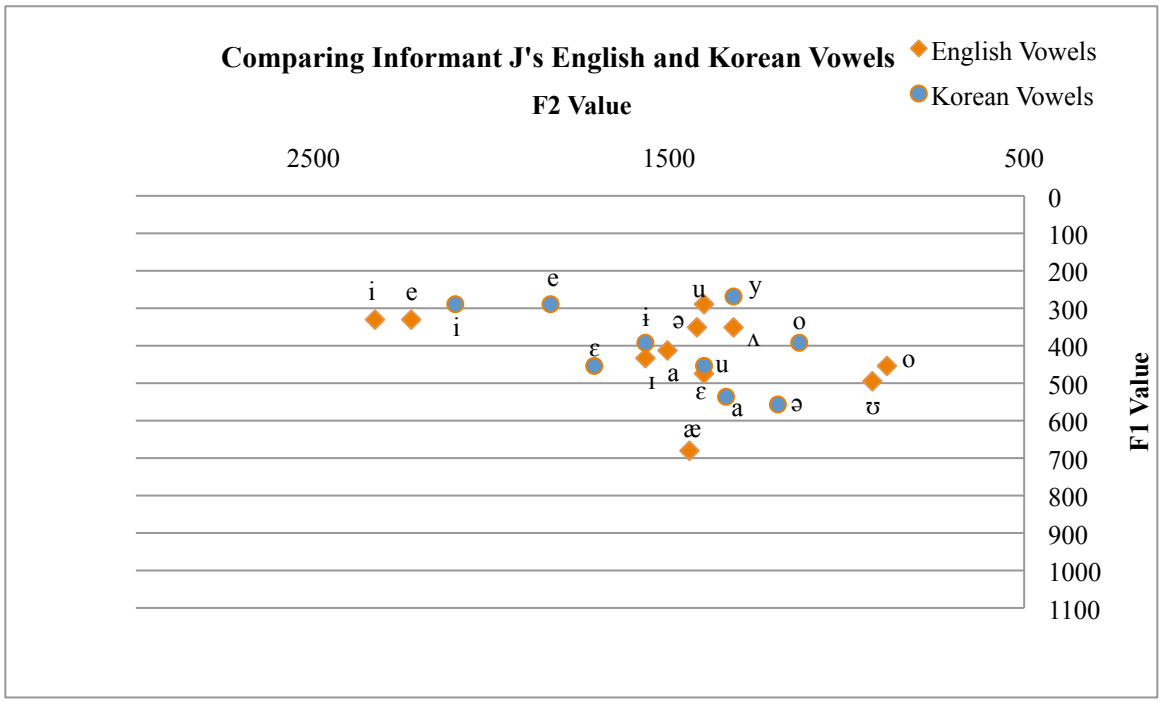

FIGURE 71. Informant J's English and Korean vowels mapped overlaid on top of one another using F1 and F2 measurements for each vowel.

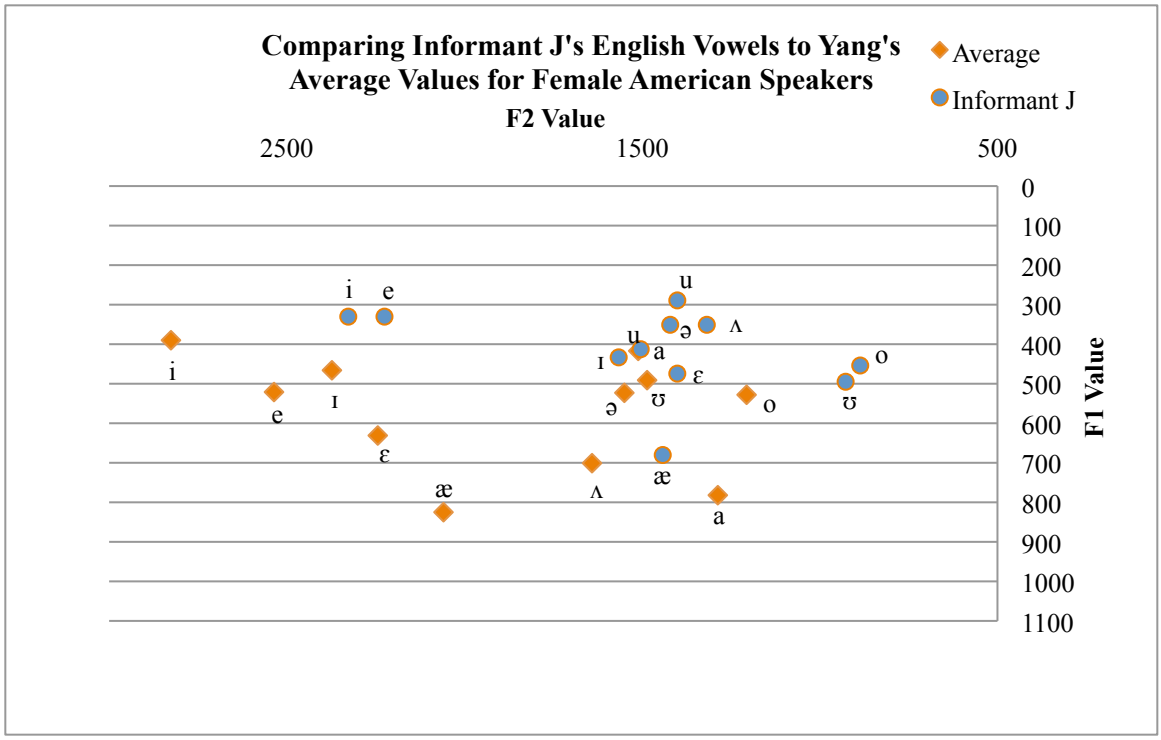

FIGURE 72. Informant J's English vowels plotted using F1 and F2 measurements overlaid on top of the vowel measurements given by Yang's average values for female American speakers.

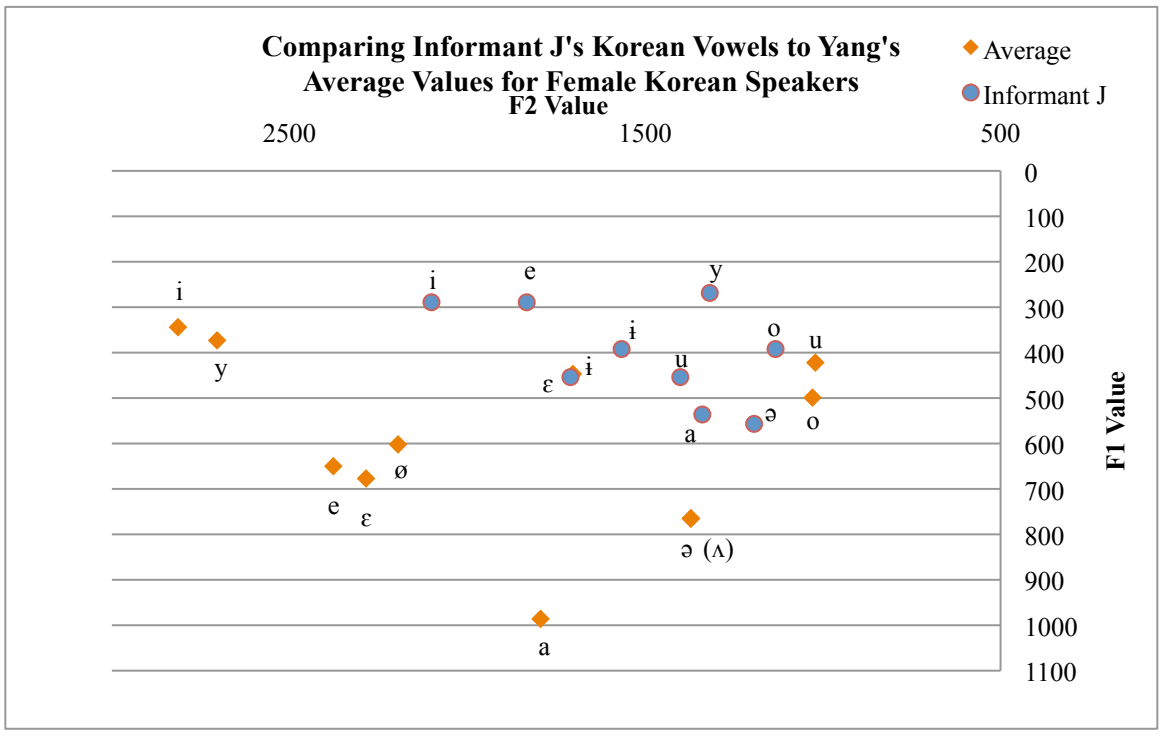

FIGURE 73. Informant J's Korean vowels plotted using F1 and F2 measurements overlaid on top of the vowel measurements given by Yang's average values for female Korean speakers.

INFORMANT K

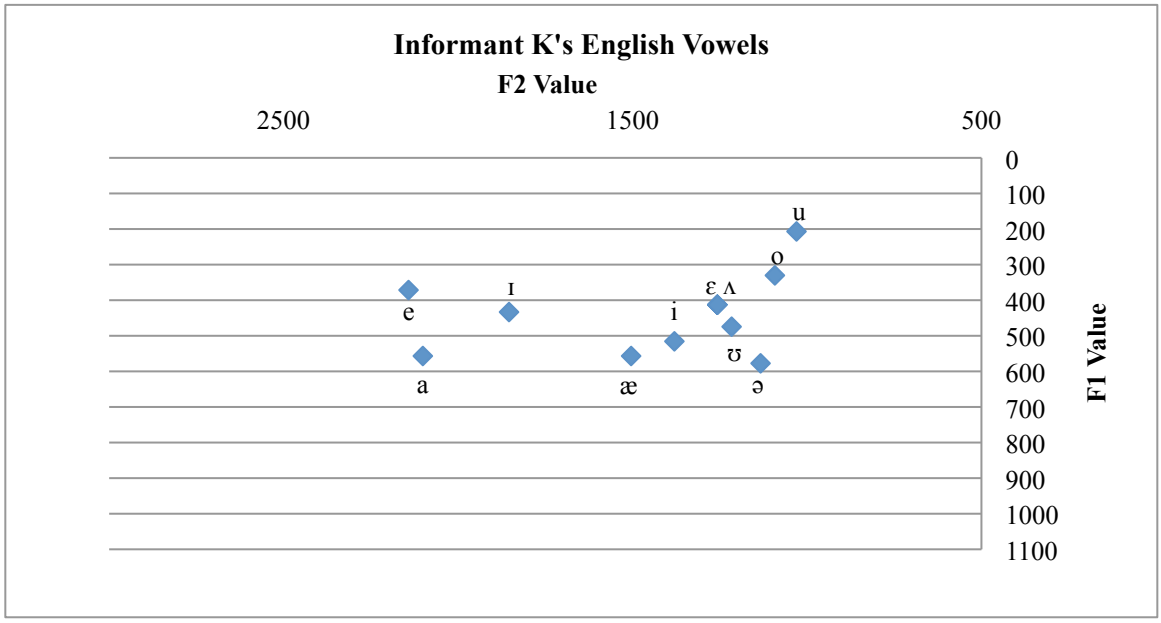

FIGURE 74. Informant K's English vowels plotted using F1 and F2 measurements for each vowel.

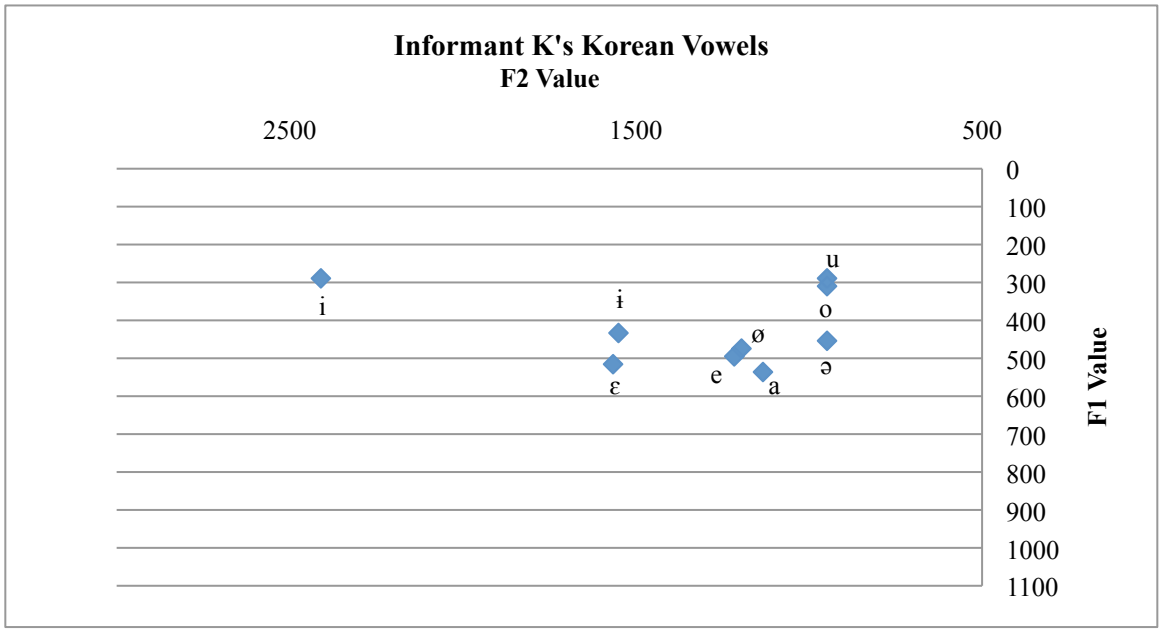

FIGURE 75. Informant K's Korean vowels plotted using F1 and F2 measurements for each vowel.

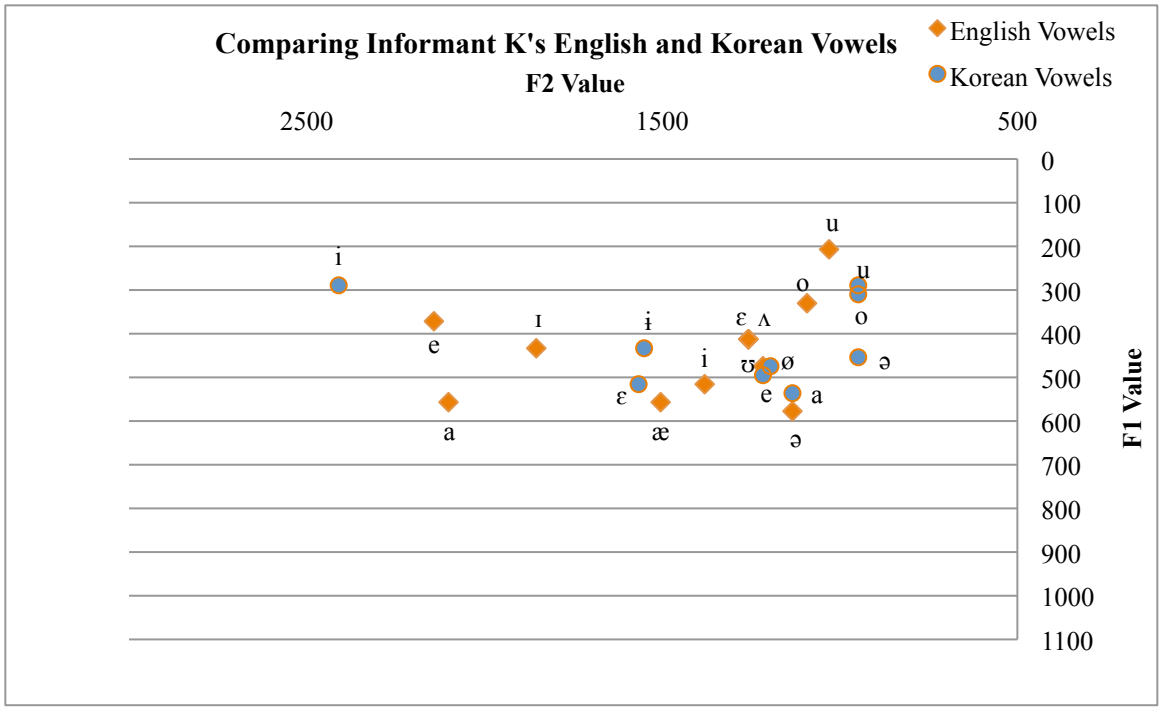

FIGURE 76. Informant K's English and Korean vowels mapped overlaid on top of one another using F1 and F2 measurements for each vowel.

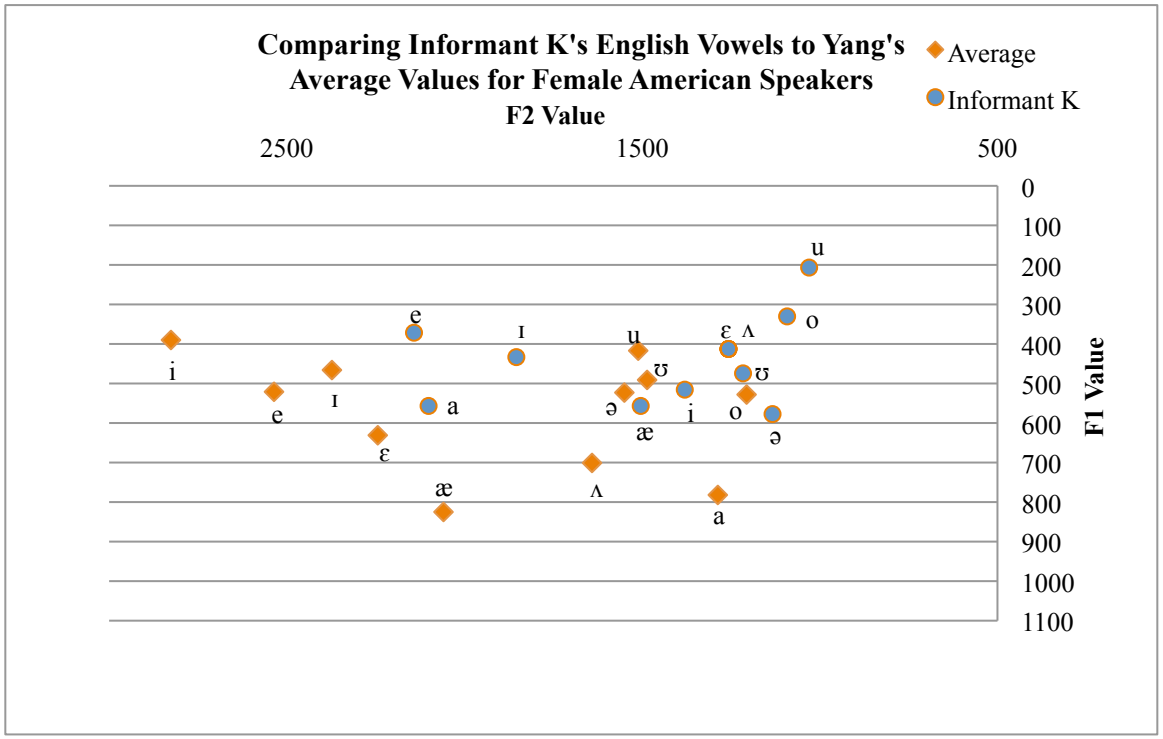

FIGURE 77. Informant K's English vowels plotted using F1 and F2 measurements overlaid on top of the vowel measurements given by Yang's average values for female American speakers.

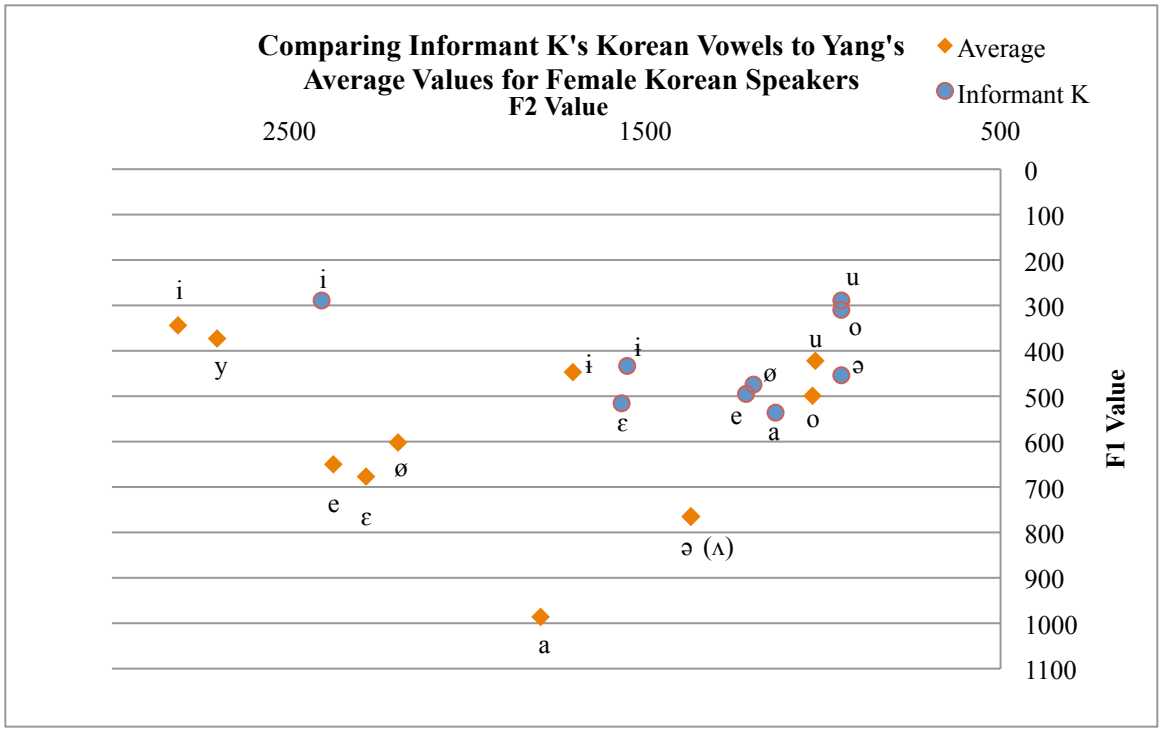

FIGURE 78. Informant K's Korean vowels plotted using F1 and F2 measurements overlaid on top of the vowel measurements given by Yang's average values for female Korean speakers.

APPENDIX C

Contextualizing Vowel Formant Measurements – Yang's Standard Deviations

The following measurements are given according to informant. For each informant, I used Yang's formant values for English and Korean vowels to calculate the difference between the formant measurements I found and those found by Yang. These differences were intended to substantiate the arguments made in Chapter 4 discussing vowel movement. These results are listed in the last column labeled "F1 - Average." The column labeled "Average" refers to Yang's measurements and the column labeled "Std Dev" refers to the standard deviations he calculated with his informants. Finally, for reference, I also produced a range by calculating the upper and lower boundaries of the standard deviation.

Informant A					
English	F1	Average	Std Dev	± Std Dev	F1 - Average
/ɪ/	515.6	466	51	415 - 517	49.6
/u/	289.2	417	29	388 - 446	127.8
/i/	556.8	390	32	358 - 422	166.8
/ʊ/	474.4	491	56	435 - 547	16.6
/a/	618.6	782	106	676 - 888	163.4
/ɛ/	433.3	631	57	580 - 688	197.7
/ʌ/	371.5	701	75	626 - 776	329.5
/æ/	433.3	825	81	744 - 906	391.7
/ə/	412.7	523	69	454 - 592	110.3
/e/	392.1	521	70	451 - 591	128.9
/o/	433.3	528	73	455 - 601	94.7

	F2	Average	Std Dev	± Std Dev	F1 - Average

/ɪ/	906.8	2373	164	2209 - 2537	1466.2
/u/	1607	1511	326	1185 - 1837	96
/i/	2410	2826	140	2686 - 2966	416
/ʊ/	1092	1486	172	1314 - 1658	394
/a/	1113	1287	97	1190 - 1384	174
/ɛ/	1380	2244	190	2054 - 2434	864
/ʌ/	1277	1641	89	1552 - 1730	364
/æ/	1710	2059	208	1851 -2267	349
/ə/	1360	1550	110	1440 - 1660	190
/e/	2224	2536	138	2398 - 2674	312
/o/	906.8	1206	183	1023 - 1389	299.2

	F3	Average	Std Dev	± Std Dev	F1 - Average
/ɪ/	1957	3014	94	2920 - 3108	1057
/u/	2451	2796	169	2627 - 2965	345
/i/	3048	3416	162	3254 - 3578	368
/ʊ/	2780	2836	154	2682 - 2990	56
/a/	2018	2563	173	2390 - 2736	545
/ɛ/	2471	2968	84	2884 - 3052	497
/ʌ/	2842	2901	108	2793 - 3009	59
/æ/	2410	2928	95	2833 - 3023	518
/ə/	2554	1927	254	1673 -2181	627
/e/	2677	2991	77	2914 - 3068	314
/o/	2410	2824	143	2681 - 2967	414
Informant A					
Korean	F1	Average	Std Dev	± Std Dev	F1 - Average
/e/	495	650	113	557 - 763	155

/ɛ/	474.4	677	108	569 - 785	202.6
/a/	989.1	986	107	879 - 1093	3.1
/o/	453.9	499	60	439 - 559	45.1
/u/	330.3	422	83	339 - 505	91.7
/ə/ (/ʌ/)	536.2	765	125	640 - 890	228.8
/i/	412.7	344	48	296 - 392	68.7
/y/	474.4	373	62	311 - 435	101.4
/ɨ/	495	447	68	379 - 515	48
/ø/	412.7	602	109	493 - 711	189.3

	F2	Average	Std Dev	± Std Dev	F1 - Average
/e/	1545	2377	77	2300 - 2454	832
/ɛ/	1627	2285	169	2177 - 2393	658
/a/	1380	1794	108	1686 - 1902	414
/o/	1133	1029	143	886 - 1172	104
/u/	1154	1021	139	882 - 1160	361
/ə/ (/ʌ/)	1010	1371	108	1263 - 1478	361
/i/	2574	2814	168	2646 - 2982	240
/y/	1607	2704	95	2609 - 2799	1097
/ɨ/	1216	1703	106	1597 - 1809	487
/ø/	1092	2195	152	2043 - 2347	1103

	F3	Average	Std Dev	± Std Dev	F1 - Average
/e/	2760	3068	117	2951 - 3185	308
/ɛ/	2762	3063	141	2922 - 3204	301
/a/	3109	2957	227	2730 - 3184	152
/o/	2636	3068	159	2909 - 3227	432

/u/	2430	3024	138	2886 - 3162	594
/ə/ (/ʌ/)	2904	3009	183	2826 - 3192	105
/i/	2965	3471	177	3294 - 3648	506
/y/	2904	3222	108	3114 -3330	318
/ɨ/	2718	2997	173	2824 - 3170	279
/ø/	2574	3013	132	2881 - 3145	439

Informant B					
English	F1	Average	Std Dev	± Std Dev	F1 - Average
/ɪ/	453.9	466	51	415 - 517	12.1
/u/	227.4	417	29	388 - 446	189.6
/i/	289.2	390	32	358 - 422	100.8
/ʊ/	453.9	491	56	435 - 547	37.1
/a/	577.4	782	106	676 - 888	204.6
/ɛ/	453.9	631	57	580 - 688	177.1
/ʌ/	453.9	701	75	626 - 776	247.1
/æ/	536.2	825	81	744 - 906	288.8
/ə/	412.7	523	69	454 - 592	110.3
/e/	248	521	70	451 - 591	273
/o/	566.8	528	73	455 - 601	38.8

	F2	Average	Std Dev	± Std Dev	F1 - Average
/ɪ/	1689	2373	164	2209 - 2537	684
/u/	1277	1511	326	1185 - 1837	234
/i/	2018	2826	140	2686 - 2966	808
/ʊ/	1298	1486	172	1314 - 1658	188
/a/	1401	1287	97	1190 - 1384	114

/ɛ/	1339	2244	190	2054 - 2434	905
/ʌ/	1648	1641	89	1552 - 1730	7
/æ/	1401	2059	208	1851 -2267	658
/ə/	1586	1550	110	1440 - 1660	36
/e/	1401	2536	138	2398 - 2674	1135
/o/	1030	1206	183	1023 - 1389	176

	F3	Average	Std Dev	± Std Dev	F1 - Average
/ɪ/	2512	3014	94	2920 - 3108	502
/u/	2595	2796	169	2627 - 2965	201
/i/	2698	3416	162	3254 - 3578	718
/ʊ/	2533	2836	154	2682 - 2990	303
/a/	2739	2563	173	2390 - 2736	176
/ɛ/	1813	2968	84	2884 - 3052	1155
/ʌ/	2512	2901	108	2793 - 3009	389
/æ/	2677	2928	95	2833 - 3023	251
/ə/	2657	1927	254	1673 -2181	730
/e/	2615	2991	77	2914 - 3068	376
/o/	2698	2824	143	2681 - 2967	126

Informant B					
Korean	F1	Average	Std Dev	± Std Dev	F1 - Average
/e/	556.8	650	113	557 - 763	93.2
/ɛ/	433.3	677	108	569 - 785	243.7
/a/	639.1	986	107	879 - 1093	346.9
/o/	350.9	499	60	439 - 559	148.1
/u/	289.2	422	83	339 - 505	132.8

/ə/ (/ʌ/)	433.3	765	125	640 - 890	331.7
/i/	248	344	48	296 - 392	96
/y/	N/A	373	62	311 - 435	N/A
/ɨ/	392.1	447	68	379 - 515	54.9
/ø/	474.4	602	109	493 - 711	127.6

	F2	Average	Std Dev	± Std Dev	F1 - Average
/e/	1854	2377	77	2300 - 2454	523
/ɛ/	1689	2285	169	2177 - 2393	596
/a/	1339	1794	108	1686 - 1902	455
/o/	1833	1029	143	886 - 1172	804
/u/	845	1021	139	882 - 1160	402.5
/ə/ (/ʌ/)	968.5	1371	108	1263 - 1478	402.5
/i/	2657	2814	168	2646 - 2982	157
/y/	N/A	2704	95	2609 - 2799	N/A
/ɨ/	1545	1703	106	1597 - 1809	158
/ø/	1483	2195	152	2043 - 2347	712

	F3	Average	Std Dev	± Std Dev	F1 - Average
/e/	2657	3068	117	2951 - 3185	411
/ɛ/	2533	3063	141	2922 - 3204	530
/a/	1977	2957	227	2730 - 3184	980
/o/	2451	3068	159	2909 - 3227	617
/u/	2677	3024	138	2886 - 3162	347
/ə/ (/ʌ/)	1833	3009	183	2826 - 3192	1176
/i/	2854	3471	177	3294 - 3648	617
/y/	N/A	3222	108	3114 -3330	N/A

/ɨ/	2245	2997	173	2824 - 3170	752
/ø/	2883	3013	132	2881 - 3145	130

Informant C					
English	F1	Average	Std Dev	± Std Dev	F1 - Average
/ɪ/	453.9	466	51	415 - 517	12.1
/u/	474.4	417	29	388 - 446	57.4
/i/	289.2	390	32	358 - 422	100.8
/ʊ/	289.2	491	56	435 - 547	201.8
/a/	536.3	782	106	676 - 888	245.7
/ɛ/	206.8	631	57	580 - 688	424.2
/ʌ/	371.5	701	75	626 - 776	329.5
/æ/	598	825	81	744 - 906	227
/ə/	412.7	523	69	454 - 592	110.3
/e/	268.6	521	70	451 - 591	252.4
/o/	495	528	73	455 - 601	33

	F2	Average	Std Dev	± Std Dev	F1 - Average
/ɪ/	1710	2373	164	2209 - 2537	663
/u/	989.1	1511	326	1185 - 1837	521.9
/i/	1833	2826	140	2686 - 2966	993
/ʊ/	742.1	1486	172	1314 - 1658	743.9
/a/	1380	1287	97	1190 - 1384	93
/ɛ/	1463	2244	190	2054 - 2434	781
/ʌ/	1442	1641	89	1552 - 1730	199
/æ/	1566	2059	208	1851 -2267	493
/ə/	1318	1550	110	1440 - 1660	232

/e/	1833	2536	138	2398 - 2674	703
/o/	865.6	1206	183	1023 - 1389	340.4

	F3	Average	Std Dev	± Std Dev	F1 - Average
/ɪ/	2821	3014	94	2920 - 3108	193
/u/	2512	2796	169	2627 - 2965	284
/i/	2492	3416	162	3254 - 3578	924
/ʊ/	2636	2836	154	2682 - 2990	200
/a/	3418	2563	173	2390 - 2736	855
/ɛ/	3048	2968	84	2884 - 3052	80
/ʌ/	2657	2901	108	2793 - 3009	244
/æ/	2574	2928	95	2833 - 3023	354
/ə/	2327	1927	254	1673 -2181	400
/e/	2657	2991	77	2914 - 3068	334
/o/	3439	2824	143	2681 - 2967	615

Informant C					
Korean	F1	Average	Std Dev	± Std Dev	F1 - Average
/e/	453.9	650	113	557 - 763	196.1
/ɛ/	536.2	677	108	569 - 785	140.8
/a/	536.2	986	107	879 - 1093	449.8
/o/	309.8	499	60	439 - 559	189.2
/u/	330.3	422	83	339 - 505	91.7
/ə/ (/ʌ/)	392.1	765	125	640 - 890	372.9
/i/	330.3	344	48	296 - 392	13.7
/y/	N/A	373	62	311 - 435	N/A
/ɨ/	556.8	447	68	379 - 515	109.8

/ø/	330.3	602	109	493 - 711	271.7

	F2	Average	Std Dev	± Std Dev	F1 - Average
/e/	1689	2377	77	2300 - 2454	688
/ɛ/	1524	2285	169	2177 - 2393	761
/a/	1421	1794	108	1686 - 1902	373
/o/	1257	1029	143	886 - 1172	228
/u/	947.9	1021	139	882 - 1160	464.2
/ə/ (/ʌ/)	906.8	1371	108	1263 - 1478	464.2
/i/	2183	2814	168	2646 - 2982	631
/y/	N/A	2704	95	2609 - 2799	N/A
/ɨ/	1442	1703	106	1597 - 1809	261
/ø/	1545	2195	152	2043 - 2347	650

	F3	Average	Std Dev	± Std Dev	F1 - Average
/e/	2821	3068	117	2951 - 3185	247
/ɛ/	2986	3063	141	2922 - 3204	77
/a/	2698	2957	227	2730 - 3184	259
/o/	2512	3068	159	2909 - 3227	556
/u/	1504	3024	138	2886 - 3162	1520
/ə/ (/ʌ/)	3007	3009	183	2826 - 3192	2
/i/	2718	3471	177	3294 - 3648	753
/y/	N/A	3222	108	3114 -3330	N/A
/ɨ/	2739	2997	173	2824 - 3170	258
/ø/	2615	3013	132	2881 - 3145	398

Informant D					

English	F1	Average	Std Dev	± Std Dev	F1 - Average
/ɪ/	350.9	466	51	415 - 517	115.1
/u/	309.8	417	29	388 - 446	107.2
/i/	248	390	32	358 - 422	142
/ʊ/	330.3	491	56	435 - 547	160.7
/a/	453.9	782	106	676 - 888	328.1
/ɛ/	474.4	631	57	580 - 688	156.6
/ʌ/	371.5	701	75	626 - 776	329.5
/æ/	474.4	825	81	744 - 906	350.6
/ə/	474.4	523	69	454 - 592	48.6
/e/	330.3	521	70	451 - 591	190.7
/o/	330.3	528	73	455 - 601	197.7

	F2	Average	Std Dev	± Std Dev	F1 - Average
/ɪ/	1463	2373	164	2209 - 2537	910
/u/	947.9	1511	326	1185 - 1837	563.1
/i/	2451	2826	140	2686 - 2966	375
/ʊ/	803.3	1486	172	1314 - 1658	682.7
/a/	1463	1287	97	1190 - 1384	176
/ɛ/	1442	2244	190	2054 - 2434	802
/ʌ/	1524	1641	89	1552 - 1730	117
/æ/	1442	2059	208	1851 -2267	617
/ə/	1298	1550	110	1440 - 1660	252
/e/	1463	2536	138	2398 - 2674	1073
/o/	845	1206	183	1023 - 1389	361

	F3	Average	Std Dev	± Std Dev	F1 - Average

/ɪ/	2698	3014	94	2920 - 3108	316
/u/	2512	2796	169	2627 - 2965	284
/i/	2945	3416	162	3254 - 3578	471
/ʊ/	2821	2836	154	2682 - 2990	15
/a/	2224	2563	173	2390 - 2736	339
/ɛ/	2327	2968	84	2884 - 3052	641
/ʌ/	2883	2901	108	2793 - 3009	18
/æ/	2163	2928	95	2833 - 3023	765
/ə/	2224	1927	254	1673 -2181	297
/e/	2986	2991	77	2914 - 3068	5
/o/	2818	2824	143	2681 - 2967	6

Informant D					
Korean	F1	Average	Std Dev	± Std Dev	F1 - Average
/e/	392.1	650	113	557 - 763	257.9
/ɛ/	433.3	677	108	569 - 785	243.7
/a/	659.7	986	107	879 - 1093	326.3
/o/	433.3	499	60	439 - 559	65.7
/u/	309.8	422	83	339 - 505	112.2
/ə/ (/ʌ/)	350.9	765	125	640 - 890	414.1
/i/	474.4	344	48	296 - 392	130.4
/y/	309.8	373	62	311 - 435	63.2
/ɨ/	495	447	68	379 - 515	48
/ø/	371.5	602	109	493 - 711	230.5
	F2	Average	Std Dev	± Std Dev	F1 - Average
/e/	1483	2377	77	2300 - 2454	894
/ɛ/	2039	2285	169	2177 - 2393	246

/a/	1421	1794	108	1686 - 1902	373
/o/	1380	1029	143	886 - 1172	351
/u/	886.2	1021	139	882 - 1160	649.5
/ə/ (/ʌ/)	721.5	1371	108	1263 - 1478	649.5
/i/	2862	2814	168	2646 - 2982	48
/y/	1524	2704	95	2609 - 2799	1180
/ɨ/	1380	1703	106	1597 - 1809	323
/ø/	1689	2195	152	2043 - 2347	506

	F3	Average	Std Dev	± Std Dev	F1 - Average
/e/	2965	3068	117	2951 - 3185	103
/ɛ/	2986	3063	141	2922 - 3204	77
/a/	2307	2957	227	2730 - 3184	650
/o/	2389	3068	159	2909 - 3227	679
/u/	2574	3024	138	2886 - 3162	450
/ə/ (/ʌ/)	2780	3009	183	2826 - 3192	229
/i/	3398	3471	177	3294 - 3648	73
/y/	2677	3222	108	3114 -3330	545
/ɨ/	2451	2997	173	2824 - 3170	546
/ø/	2636	3013	132	2881 - 3145	377

Informant E					
English	F1	Average	Std Dev	± Std Dev	F1 - Average
/ɪ/	536.2	466	51	415 - 517	70.2
/u/	227.4	417	29	388 - 446	189.6
/i/	371.5	390	32	358 - 422	18.5
/ʊ/	495	491	56	435 - 547	4

/a/	598	782	106	676 - 888	184
/ɛ/	433.3	631	57	580 - 688	197.7
/ʌ/	392.1	701	75	626 - 776	308.9
/æ/	453.9	825	81	744 - 906	371.1
/ə/	392.1	523	69	454 - 592	130.9
/e/	433.3	521	70	451 - 591	87.7
/o/	515.6	528	73	455 - 601	12.4

	F2	Average	Std Dev	± Std Dev	F1 - Average
/ɪ/	1792	2373	164	2209 - 2537	581
/u/	947.9	1511	326	1185 - 1837	563.1
/i/	2595	2826	140	2686 - 2966	231
/ʊ/	1257	1486	172	1314 - 1658	229
/a/	1071	1287	97	1190 - 1384	216
/ɛ/	1524	2244	190	2054 - 2434	720
/ʌ/	1216	1641	89	1552 - 1730	425
/æ/	1380	2059	208	1851 -2267	679
/ə/	1442	1550	110	1440 - 1660	108
/e/	1915	2536	138	2398 - 2674	621
/o/	1174	1206	183	1023 - 1389	32

	F3	Average	Std Dev	± Std Dev	F1 - Average
/ɪ/	2760	3014	94	2920 - 3108	254
/u/	2492	2796	169	2627 - 2965	304
/i/	3068	3416	162	3254 - 3578	348
/ʊ/	2471	2836	154	2682 - 2990	365
/a/	1792	2563	173	2390 - 2736	771

/ɛ/	2224	2968	84	2884 - 3052	744
/ʌ/	2574	2901	108	2793 - 3009	327
/æ/	2018	2928	95	2833 - 3023	910
/ə/	2698	1927	254	1673 -2181	771
/e/	2821	2991	77	2914 - 3068	170
/o/	2760	2824	143	2681 - 2967	64

Informant E					
Korean	F1	Average	Std Dev	± Std Dev	F1 - Average
/e/	577.4	650	113	557 - 763	72.6
/ɛ/	474.4	677	108	569 - 785	202.6
/a/	680.3	986	107	879 - 1093	305.7
/o/	268.6	499	60	439 - 559	230.4
/u/	412.7	422	83	339 - 505	9.3
/ə/ (/ʌ/)	412.7	765	125	640 - 890	352.3
/i/	265.1	344	48	296 - 392	78.9
/y/	N/A	373	62	311 - 435	N/A
/ɨ/	474.4	447	68	379 - 515	27.4
/ø/	433.3	602	109	493 - 711	168.7

	F2	Average	Std Dev	± Std Dev	F1 - Average
/e/	1545	2377	77	2300 - 2454	832
/ɛ/	1545	2285	169	2177 - 2393	740
/a/	1360	1794	108	1686 - 1902	434
/o/	1566	1029	143	886 - 1172	537
/u/	1113	1021	139	882 - 1160	443.7
/ə/ (/ʌ/)	927.3	1371	108	1263 - 1478	443.7

/i/	2505	2814	168	2646 - 2982	309
/y/	N/A	2704	95	2609 - 2799	N/A
/ɨ/	1483	1703	106	1597 - 1809	220
/ø/	1751	2195	152	2043 - 2347	444

	F3	Average	Std Dev	± Std Dev	F1 - Average
/e/	1998	3068	117	2951 - 3185	1070
/ɛ/	2862	3063	141	2922 - 3204	201
/a/	2554	2957	227	2730 - 3184	403
/o/	2204	3068	159	2909 - 3227	864
/u/	2595	3024	138	2886 - 3162	429
/ə/ (/ʌ/)	2574	3009	183	2826 - 3192	435
/i/	3295	3471	177	3294 - 3648	176
/y/	N/A	3222	108	3114 -3330	N/A
/ɨ/	2821	2997	173	2824 - 3170	176
/ø/	2718	3013	132	2881 - 3145	295

<u>Informant F</u>					
English	F1	Average	Std Dev	± Std Dev	F1 - Average
/ɪ/	474.4	466	51	415 - 517	8.4
/u/	268.6	417	29	388 - 446	148.4
/i/	286.6	390	32	358 - 422	103.4
/ʊ/	350.9	491	56	435 - 547	140.1
/a/	515.6	782	106	676 - 888	266.4
/ɛ/	453.9	631	57	580 - 688	177.1
/ʌ/	289.2	701	75	626 - 776	411.8
/æ/	495	825	81	744 - 906	330

/ə/	536.2	523	69	454 - 592	13.2
/e/	556.8	521	70	451 - 591	35.8
/o/	433.3	528	73	455 - 601	94.7

	F2	Average	Std Dev	± Std Dev	F1 - Average
/ɪ/	1586	2373	164	2209 - 2537	787
/u/	989.1	1511	326	1185 - 1837	521.9
/i/	2274.4	2826	140	2686 - 2966	551.6
/ʊ/	886.2	1486	172	1314 - 1658	599.8
/a/	1607	1287	97	1190 - 1384	320
/ɛ/	1483	2244	190	2054 - 2434	761
/ʌ/	1504	1641	89	1552 - 1730	137
/æ/	1421	2059	208	1851 -2267	638
/ə/	1339	1550	110	1440 - 1660	211
/e/	1874	2536	138	2398 - 2674	662
/o/	1318	1206	183	1023 - 1389	112

	F3	Average	Std Dev	± Std Dev	F1 - Average
/ɪ/	2204	3014	94	2920 - 3108	810
/u/	2268	2796	169	2627 - 2965	528
/i/	2682.6	3416	162	3254 - 3578	733.4
/ʊ/	2410	2836	154	2682 - 2990	426
/a/	2286	2563	173	2390 - 2736	277
/ɛ/	2204	2968	84	2884 - 3052	764
/ʌ/	2512	2901	108	2793 - 3009	389
/æ/	2286	2928	95	2833 - 3023	642
/ə/	2883	1927	254	1673 -2181	956

/e/	2718	2991	77	2914 - 3068	273
/o/	2204	2824	143	2681 - 2967	620

Informant F					
Korean	F1	Average	Std Dev	± Std Dev	F1 - Average
/e/	412.7	650	113	557 - 763	237.3
/ɛ/	433.3	677	108	569 - 785	243.7
/a/	515.6	986	107	879 - 1093	470.4
/o/	330.3	499	60	439 - 559	168.7
/u/	474.4	422	83	339 - 505	52.4
/ə/ (/ʌ/)	515.6	765	125	640 - 890	249.4
/i/	474.4	344	48	296 - 392	130.4
/y/	474.4	373	62	311 - 435	101.4
/ɨ/	309.8	447	68	379 - 515	137.2
/ø/	N/A	602	109	493 - 711	N/A

	F2	Average	Std Dev	± Std Dev	F1 - Average
/e/	1442	2377	77	2300 - 2454	935
/ɛ/	1360	2285	169	2177 - 2393	925
/a/	1524	1794	108	1686 - 1902	270
/o/	1442	1029	143	886 - 1172	413
/u/	1051	1021	139	882 - 1160	11
/ə/ (/ʌ/)	1360	1371	108	1263 - 1478	11
/i/	2348	2814	168	2646 - 2982	466
/y/	2183	2704	95	2609 - 2799	
/ɨ/	1442	1703	106	1597 - 1809	261
/ø/	N/A	2195	152	2043 - 2347	N/A

	F3	Average	Std Dev	± Std Dev	F1 - Average
/e/	2821	3068	117	2951 - 3185	247
/ɛ/	2471	3063	141	2922 - 3204	592
/a/	2451	2957	227	2730 - 3184	506
/o/	2286	3068	159	2909 - 3227	782
/u/	2265	3024	138	2886 - 3162	759
/ə/ (/ʌ/)	2245	3009	183	2826 - 3192	764
/i/	3068	3471	177	3294 - 3648	403
/y/	2821	3222	108	3114 -3330	401
/ɨ/	2780	2997	173	2824 - 3170	217
/ø/	N/A	3013	132	2881 - 3145	N/A

Informant G					
English	F1	Average	Std Dev	± Std Dev	F1 - Average
/ɪ/	371.5	466	51	415 - 517	94.5
/u/	371.5	417	29	388 - 446	45.5
/i/	350.9	390	32	358 - 422	39.1
/ʊ/	350.9	491	56	435 - 547	140.1
/a/	474.4	782	106	676 - 888	307.6
/ɛ/	474.4	631	57	580 - 688	156.6
/ʌ/	495	701	75	626 - 776	206
/æ/	783.2	825	81	744 - 906	41.8
/ə/	474.4	523	69	454 - 592	48.6
/e/	350.9	521	70	451 - 591	170.1
/o/	350.9	528	73	455 - 601	177.1

	F2	Average	Std Dev	± Std Dev	F1 - Average
/ɪ/	1421	2373	164	2209 - 2537	952
/u/	947.9	1511	326	1185 - 1837	563.1
/i/	2018	2826	140	2686 - 2966	808
/ʊ/	1133	1486	172	1314 - 1658	353
/a/	1483	1287	97	1190 - 1384	196
/ɛ/	1442	2244	190	2054 - 2434	802
/ʌ/	1380	1641	89	1552 - 1730	261
/æ/	1463	2059	208	1851 -2267	596
/ə/	1439	1550	110	1440 - 1660	111
/e/	2060	2536	138	2398 - 2674	476
/o/	824.4	1206	183	1023 - 1389	381.6

	F3	Average	Std Dev	± Std Dev	F1 - Average
/ɪ/	2265	3014	94	2920 - 3108	749
/u/	2348	2796	169	2627 - 2965	448
/i/	2862	3416	162	3254 - 3578	554
/ʊ/	2739	2836	154	2682 - 2990	97
/a/	2307	2563	173	2390 - 2736	256
/ɛ/	2121	2968	84	2884 - 3052	847
/ʌ/	2183	2901	108	2793 - 3009	718
/æ/	2286	2928	95	2833 - 3023	642
/ə/	2379	1927	254	1673 -2181	452
/e/	2636	2991	77	2914 - 3068	355
/o/	2142	2824	143	2681 - 2967	682

Informant G					

Korean	F1	Average	Std Dev	± Std Dev	F1 - Average
/e/	577.4	650	113	557 - 763	72.6
/ɛ/	433.3	677	108	569 - 785	243.7
/a/	845	986	107	879 - 1093	141
/o/	371.5	499	60	439 - 559	127.5
/u/	392.1	422	83	339 - 505	29.9
/ə/ (/ʌ/)	392.1	765	125	640 - 890	372.9
/i/	412.7	344	48	296 - 392	68.7
/y/	N/A	373	62	311 - 435	N/A
/ɨ/	415.5	447	68	379 - 515	31.5
/ø/	474.4	602	109	493 - 711	127.6

	F2	Average	Std Dev	± Std Dev	F1 - Average
/e/	1524	2377	77	2300 - 2454	853
/ɛ/	1442	2285	169	2177 - 2393	843
/a/	1380	1794	108	1686 - 1902	414
/o/	906.8	1029	143	886 - 1172	122.2
/u/	1216	1021	139	882 - 1160	567.2
/ə/ (/ʌ/)	803.8	1371	108	1263 - 1478	567.2
/i/	2101	2814	168	2646 - 2982	713
/y/	N/A	2704	95	2609 - 2799	N/A
/ɨ/	1698.1	1703	106	1597 - 1809	4.9
/ø/	1339	2195	152	2043 - 2347	856

	F3	Average	Std Dev	± Std Dev	F1 - Average
/e/	2821	3068	117	2951 - 3185	247
/ɛ/	2821	3063	141	2922 - 3204	242

/a/	2265	2957	227	2730 - 3184	692
/o/	2389	3068	159	2909 - 3227	679
/u/	2245	3024	138	2886 - 3162	779
/ə/ (/ʌ/)	2224	3009	183	2826 - 3192	785
/i/	2842	3471	177	3294 - 3648	629
/y/	N/A	3222	108	3114 -3330	N/A
/ɨ/	2718.5	2997	173	2824 - 3170	278.5
/ø/	2739	3013	132	2881 - 3145	274

Informant H					
English	F1	Average	Std Dev	± Std Dev	F1 - Average
/ɪ/	412.7	466	51	415 - 517	53.3
/u/	330.3	417	29	388 - 446	86.7
/i/	330.3	390	32	358 - 422	59.7
/ʊ/	577.4	491	56	435 - 547	86.4
/a/	495	782	106	676 - 888	287
/ɛ/	392.1	631	57	580 - 688	238.9
/ʌ/	350.9	701	75	626 - 776	350.1
/æ/	598	825	81	744 - 906	227
/ə/	433.3	523	69	454 - 592	89.7
/e/	309.8	521	70	451 - 591	211.2
/o/	515.6	528	73	455 - 601	12.4

	F2	Average	Std Dev	± Std Dev	F1 - Average
/ɪ/	1504	2373	164	2209 - 2537	869
/u/	865.6	1511	326	1185 - 1837	645.4
/i/	2142	2826	140	2686 - 2966	684

/ʊ/	927.3	1486	172	1314 - 1658	558.7
/a/	1813	1287	97	1190 - 1384	526
/ɛ/	1771	2244	190	2054 - 2434	473
/ʌ/	906.8	1641	89	1552 - 1730	734.2
/æ/	1627	2059	208	1851 -2267	432
/ə/	927.3	1550	110	1440 - 1660	622.7
/e/	2121	2536	138	2398 - 2674	415
/o/	865.6	1206	183	1023 - 1389	340.4

	F3	Average	Std Dev	± Std Dev	F1 - Average
/ɪ/	2224	3014	94	2920 - 3108	790
/u/	2204	2796	169	2627 - 2965	592
/i/	2636	3416	162	3254 - 3578	780
/ʊ/	2698	2836	154	2682 - 2990	138
/a/	2842	2563	173	2390 - 2736	279
/ɛ/	2636	2968	84	2884 - 3052	332
/ʌ/	2204	2901	108	2793 - 3009	697
/æ/	2657	2928	95	2833 - 3023	271
/ə/	2060	1927	254	1673 -2181	133
/e/	2883	2991	77	2914 - 3068	108
/o/	2751.8	2824	143	2681 - 2967	72.2

Informant H					
Korean	F1	Average	Std Dev	± Std Dev	F1 - Average
/e/	412.7	650	113	557 - 763	237.3
/ɛ/	712.5	677	108	569 - 785	35.5
/a/	742.1	986	107	879 - 1093	243.9

/o/	289.2	499	60	439 - 559	209.8
/u/	453.9	422	83	339 - 505	31.9
/ə/ (/ʌ/)	474.4	765	125	640 - 890	290.6
/i/	639.1	344	48	296 - 392	295.1
/y/	N/A	373	62	311 - 435	N/A
/ɨ/	289.2	447	68	379 - 515	157.8
/ø/	289.2	602	109	493 - 711	312.8

	F2	Average	Std Dev	± Std Dev	F1 - Average
/e/	1936	2377	77	2300 - 2454	441
/ɛ/	1813	2285	169	2177 - 2393	472
/a/	1442	1794	108	1686 - 1902	352
/o/	762.7	1029	143	886 - 1172	266.3
/u/	865.6	1021	139	882 - 1160	443.7
/ə/ (/ʌ/)	927.3	1371	108	1263 - 1478	443.7
/i/	2595	2814	168	2646 - 2982	219
/y/	N/A	2704	95	2609 - 2799	N/A
/ɨ/	1504	1703	106	1597 - 1809	199
/ø/	1792	2195	152	2043 - 2347	403

	F3	Average	Std Dev	± Std Dev	F1 - Average
/e/	2801	3068	117	2951 - 3185	267
/ɛ/	2883	3063	141	2922 - 3204	180
/a/	2142	2957	227	2730 - 3184	815
/o/	2286	3068	159	2909 - 3227	782
/u/	2615	3024	138	2886 - 3162	409
/ə/ (/ʌ/)	2492	3009	183	2826 - 3192	517

/i/	3830	3471	177	3294 - 3648	359
/y/	N/A	3222	108	3114 -3330	N/A
/ɨ/	2368	2997	173	2824 - 3170	629
/ø/	2739	3013	132	2881 - 3145	274

Informant I					
English	F1	Average	Std Dev	± Std Dev	F1 - Average
/ɪ/	618.6	466	51	415 - 517	152.6
/u/	309.8	417	29	388 - 446	107.2
/i/	371.5	390	32	358 - 422	18.5
/ʊ/	433.3	491	56	435 - 547	57.7
/a/	639.1	782	106	676 - 888	142.9
/ɛ/	556.8	631	57	580 - 688	74.2
/ʌ/	309.8	701	75	626 - 776	391.2
/æ/	618.6	825	81	744 - 906	206.4
/ə/	495	523	69	454 - 592	28
/e/	371.5	521	70	451 - 591	149.5
/o/	350.9	528	73	455 - 601	177.1

	F2	Average	Std Dev	± Std Dev	F1 - Average
/ɪ/	1607	2373	164	2209 - 2537	766
/u/	824.4	1511	326	1185 - 1837	686.6
/i/	2533	2826	140	2686 - 2966	293
/ʊ/	1257	1486	172	1314 - 1658	229
/a/	1648	1287	97	1190 - 1384	361
/ɛ/	1545	2244	190	2054 - 2434	699
/ʌ/	1524	1641	89	1552 - 1730	117

/æ/	1627	2059	208	1851 -2267	432
/ə/	1504	1550	110	1440 - 1660	46
/e/	1874	2536	138	2398 - 2674	662
/o/	824.4	1206	183	1023 - 1389	381.6

	F3	Average	Std Dev	± Std Dev	F1 - Average
/ɪ/	2595	3014	94	2920 - 3108	419
/u/	2471	2796	169	2627 - 2965	325
/i/	3036.8	3416	162	3254 - 3578	379.2
/ʊ/	2471	2836	154	2682 - 2990	365
/a/	2965	2563	173	2390 - 2736	402
/ɛ/	2760	2968	84	2884 - 3052	208
/ʌ/	2430	2901	108	2793 - 3009	471
/æ/	2471	2928	95	2833 - 3023	457
/ə/	2327	1927	254	1673 -2181	400
/e/	2451	2991	77	2914 - 3068	540
/o/	2492	2824	143	2681 - 2967	332

<u>Informant I</u>					
Korean	F1	Average	Std Dev	± Std Dev	F1 - Average
/e/	536.2	650	113	557 - 763	113.8
/ɛ/	474	677	108	569 - 785	203
/a/	906.8	986	107	879 - 1093	79.2
/o/	289.2	499	60	439 - 559	209.8
/u/	309.8	422	83	339 - 505	112.2
/ə/ (/ʌ/)	268.6	765	125	640 - 890	496.4
/i/	289.2	344	48	296 - 392	54.8

/y/	N/A	373	62	311 - 435	N/A
/ɨ/	268.6	447	68	379 - 515	178.4
/ø/	371.5	602	109	493 - 711	230.5

	F2	Average	Std Dev	± Std Dev	F1 - Average
/e/	2183	2377	77	2300 - 2454	194
/ɛ/	1524	2285	169	2177 - 2393	761
/a/	1504	1794	108	1686 - 1902	290
/o/	865.6	1029	143	886 - 1172	163.4
/u/	1010	1021	139	882 - 1160	567.2
/ə/ (/ʌ/)	803.8	1371	108	1263 - 1478	567.2
/i/	2615	2814	168	2646 - 2982	199
/y/	N/A	2704	95	2609 - 2799	N/A
/ɨ/	1421	1703	106	1597 - 1809	282
/ø/	1710	2195	152	2043 - 2347	485
	F3	Average	Std Dev	± Std Dev	F1 - Average
/e/	2883	3068	117	2951 - 3185	185
/ɛ/	2760	3063	141	2922 - 3204	303
/a/	2657	2957	227	2730 - 3184	300
/o/	2163	3068	159	2909 - 3227	905
/u/	2389	3024	138	2886 - 3162	635
/ə/ (/ʌ/)	2718	3009	183	2826 - 3192	291
/i/	2956.5	3471	177	3294 - 3648	514.5
/y/	N/A	3222	108	3114 -3330	N/A
/ɨ/	2615	2997	173	2824 - 3170	382
/ø/	2389	3013	132	2881 - 3145	624

Informant J					
English	F1	Average	Std Dev	± Std Dev	F1 - Average
/ɪ/	433.3	466	51	415 - 517	32.7
/u/	289.2	417	29	388 - 446	127.8
/i/	330.3	390	32	358 - 422	59.7
/ʊ/	495	491	56	435 - 547	4
/a/	412.7	782	106	676 - 888	369.3
/ɛ/	474.4	631	57	580 - 688	156.6
/ʌ/	350.9	701	75	626 - 776	350.1
/æ/	680.3	825	81	744 - 906	144.7
/ə/	350.9	523	69	454 - 592	172.1
/e/	330.3	521	70	451 - 591	190.7
/o/	453.9	528	73	455 - 601	74.1

	F2	Average	Std Dev	± Std Dev	F1 - Average
/ɪ/	1566	2373	164	2209 - 2537	807
/u/	1401	1511	326	1185 - 1837	110
/i/	2327	2826	140	2686 - 2966	499
/ʊ/	927.3	1486	172	1314 - 1658	558.7
/a/	1504	1287	97	1190 - 1384	217
/ɛ/	1401	2244	190	2054 - 2434	843
/ʌ/	1318	1641	89	1552 - 1730	323
/æ/	1442	2059	208	1851 -2267	617
/ə/	1421	1550	110	1440 - 1660	129
/e/	2225.1	2536	138	2398 - 2674	310.9
/o/	886.2	1206	183	1023 - 1389	319.8

	F3	Average	Std Dev	± Std Dev	F1 - Average
/ɪ/	2801	3014	94	2920 - 3108	213
/u/	2245	2796	169	2627 - 2965	551
/i/	2718	3416	162	3254 - 3578	698
/ʊ/	2410	2836	154	2682 - 2990	426
/a/	2245	2563	173	2390 - 2736	318
/ɛ/	2327	2968	84	2884 - 3052	641
/ʌ/	2204	2901	108	2793 - 3009	697
/æ/	2348	2928	95	2833 - 3023	580
/ə/	2245	1927	254	1673 -2181	318
/e/	2671.4	2991	77	2914 - 3068	319.6
/o/	2265	2824	143	2681 - 2967	559

Informant J					
Korean	F1	Average	Std Dev	± Std Dev	F1 - Average
/e/	289.2	650	113	557 - 763	360.8
/ɛ/	453.9	677	108	569 - 785	223.1
/a/	536.2	986	107	879 - 1093	449.8
/o/	392.1	499	60	439 - 559	106.9
/u/	453.9	422	83	339 - 505	31.9
/ə/ (/ʌ/)	556.8	765	125	640 - 890	208.2
/i/	289.2	344	48	296 - 392	54.8
/y/	268.6	373	62	311 - 435	104.4
/ɨ/	392.1	447	68	379 - 515	54.9
/ø/	N/A	602	109	493 - 711	N/A

	F2	Average	Std Dev	± Std Dev	F1 - Average

/e/	1833	2377	77	2300 - 2454	544
/ɛ/	1710	2285	169	2177 - 2393	575
/a/	1339	1794	108	1686 - 1902	455
/o/	1133	1029	143	886 - 1172	-104
/u/	1401	1021	139	882 - 1160	177.8
/ə/ (/ʌ/)	1193.2	1371	108	1263 - 1478	177.8
/i/	2101	2814	168	2646 - 2982	713
/y/	1318	2704	95	2609 - 2799	1386
/ɨ/	1566	1703	106	1597 - 1809	137
/ø/	N/A	2195	152	2043 - 2347	N/A

	F3	Average	Std Dev	± Std Dev	F1 - Average
/e/	2657	3068	117	2951 - 3185	411
/ɛ/	2636	3063	141	2922 - 3204	427
/a/	2451	2957	227	2730 - 3184	506
/o/	2286	3068	159	2909 - 3227	782
/u/	2657	3024	138	2886 - 3162	367
/ə/ (/ʌ/)	2533	3009	183	2826 - 3192	476
/i/	2842	3471	177	3294 - 3648	629
/y/	2060	3222	108	3114 -3330	1162
/ɨ/	2512	2997	173	2824 - 3170	485
/ø/	N/A	3013	132	2881 - 3145	N/A

<u>Informant K</u>					
English	F1	Average	Std Dev	± Std Dev	F1 - Average
/ɪ/	433.3	466	51	415 - 517	32.7
/u/	206.8	417	29	388 - 446	210.2

/i/	515.6	390	32	358 - 422	125.6
/ʊ/	474.4	491	56	435 - 547	16.6
/a/	556.8	782	106	676 - 888	225.2
/ɛ/	412.7	631	57	580 - 688	218.3
/ʌ/	412.7	701	75	626 - 776	288.3
/æ/	556.8	825	81	744 - 906	268.2
/ə/	577.4	523	69	454 - 592	56.4
/e/	371.5	521	70	451 - 591	149.5
/o/	330.3	528	73	455 - 601	197.7

	F2	Average	Std Dev	± Std Dev	F1 - Average
/ɪ/	1854	2373	164	2209 - 2537	519
/u/	1030	1511	326	1185 - 1837	481
/i/	1380	2826	140	2686 - 2966	1446
/ʊ/	1216	1486	172	1314 - 1658	270
/a/	2101	1287	97	1190 - 1384	814
/ɛ/	1257	2244	190	2054 - 2434	987
/ʌ/	1257	1641	89	1552 - 1730	384
/æ/	1504	2059	208	1851 -2267	555
/ə/	1133	1550	110	1440 - 1660	417
/e/	2142	2536	138	2398 - 2674	394
/o/	1092	1206	183	1023 - 1389	114

	F3	Average	Std Dev	± Std Dev	F1 - Average
/ɪ/	2389	3014	94	2920 - 3108	625
/u/	2492	2796	169	2627 - 2965	304
/i/	2183	3416	162	3254 - 3578	1233

/ʊ/	2533	2836	154	2682 - 2990	303
/a/	2904	2563	173	2390 - 2736	341
/ɛ/	2183	2968	84	2884 - 3052	785
/ʌ/	2245	2901	108	2793 - 3009	656
/æ/	2204	2928	95	2833 - 3023	724
/ə/	2080	1927	254	1673 -2181	153
/e/	2744.9	2991	77	2914 - 3068	246.1
/o/	2163	2824	143	2681 - 2967	661

Informant K					
Korean	F1	Average	Std Dev	± Std Dev	F1 - Average
/e/	495	650	113	557 - 763	155
/ɛ/	515.6	677	108	569 - 785	161.4
/a/	536.2	986	107	879 - 1093	449.8
/o/	309.8	499	60	439 - 559	189.2
/u/	289.2	422	83	339 - 505	132.8
/ə/ (/ʌ/)	453.9	765	125	640 - 890	311.1
/i/	289.2	344	48	296 - 392	54.8
/y/	N/A	373	62	311 - 435	N/A
/ɨ/	433.3	447	68	379 - 515	13.7
/ø/	474.4	602	109	493 - 711	127.6

	F2	Average	Std Dev	± Std Dev	F1 - Average
/e/	1216	2377	77	2300 - 2454	1161
/ɛ/	1566	2285	169	2177 - 2393	719
/a/	1133	1794	108	1686 - 1902	661
/o/	947.9	1029	143	886 - 1172	81.1

/u/	947.9	1021	139	882 - 1160	73.1
/ə/ (/ʌ/)	947.9	1371	108	1263 - 1478	423.1
/i/	2410	2814	168	2646 - 2982	404
/y/	N/A	2704	95	2609 - 2799	N/A
/ɨ/	1550.4	1703	106	1597 - 1809	152.6
/ø/	1195	2195	152	2043 - 2347	1000

	F3	Average	Std Dev	± Std Dev	F1 - Average
/e/	2245	3068	117	2951 - 3185	823
/ɛ/	2451	3063	141	2922 - 3204	612
/a/	2368	2957	227	2730 - 3184	589
/o/	2368	3068	159	2909 - 3227	700
/u/	2368	3024	138	2886 - 3162	656
/ə/ (/ʌ/)	2224	3009	183	2826 - 3192	785
/i/	2986	3471	177	3294 - 3648	485
/y/	N/A	3222	108	3114 -3330	N/A
/ɨ/	2781.7	2997	173	2824 - 3170	215.3
/ø/	2587.8	3013	132	2881 - 3145	425.2

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